FY 2004
PROGRAM SOLICITATION

Opening Date: November 3, 2003
Closing Date: January 30, 2004

NIST-04-SBIR

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology

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US DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

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US DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

1.0 PROGRAM DESCRIPTION

1.01 Introduction

The Department of Commerce (DOC) National Institute of Standards and Technology (NIST) invites small businesses to submit research proposals under this solicitation. Firms with strong research capabilities in any of the areas listed in Section 9 of this solicitation are encouraged to participate. **Unsolicited proposals are not accepted under the SBIR program**.

Objectives of this program include stimulating technological innovation in the private sector and strengthening the role of small business in meeting Federal research and development (R&D) needs. This program also seeks to increase the commercial application of innovations derived from Federal research and improve the return on investment from federally funded research for the economic benefit of the Nation.

1.02 Three-Phase Program

The "Small Business Research and Development Enhancement Act of 1992", as amended, requires the Department of Commerce to establish a three-phase SBIR program by reserving a percentage of its extramural R&D budget to be awarded to small business concerns for innovation research.

This document solicits Phase 1 proposals only.

NIST has the unilateral right to select SBIR research topics and awardees in both Phase 1 and Phase 2, and to make several or no awards under a given topic.

1.02.01 Phase 1 - Feasibility Research

The purpose of Phase 1 is to determine the technical feasibility of the proposed research and the quality of performance of the small business concern receiving an award. Therefore, the proposal should concentrate on research that will significantly contribute to proving the feasibility of the proposed research, a prerequisite to further support in Phase 2.

1.02.02 Phase 2 - Research and Development

Only firms that receive Phase 1 awards will be given the opportunity of submitting a Phase 2 proposal immediately following completion of Phase 1.

Phase 2 is the R&D or prototype development phase. It will require a comprehensive proposal outlining the research in detail. Further information regarding Phase 2 proposal requirements will be provided to all firms receiving Phase 1 awards.

1.02.03 Phase 3 - Commercialization

In Phase 3, it is intended that non-SBIR capital be used by the small business to pursue commercial applications of Phase 2.

1.03 Eligibility

Each organization submitting a proposal for both Phase 1 and Phase 2 **must** qualify as a small business concern (Section 2.10) for research or R&D purposes (Section 2.7) at the time of award. In addition, the primary employment of the principal investigator must be with the small business at the time of the award and during the conduct of the proposed research. More than one-half of the principal investigator's time must be spent with the small business for the period covered by the award. **Primary employment with a small business precludes full-time employment with another organization.**

Also, for both Phase 1 and Phase 2, the work must be performed in the United States. "United States" means the fifty states, the territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia. However, based on a rare and unique circumstance, for example, a supply or material or other item or project requirement that is not available in the United States, agencies may allow that particular portion of the R/R&D work to be performed or obtained in a country outside of the United States. Approval by the funding agreement officer after consultation with the agency SBIR Program Manager/Coordinator for each such specific condition must be in writing.

Joint ventures and limited partnerships are eligible, provided the entity created qualifies as a small business as defined in this solicitation. **Consultative arrangements between firms and universities or other non-profit organizations are encouraged, with the small business serving as the prime contractor.**

For Phase 1, a minimum of two-thirds of the research and/or analytical effort must be performed by the awardee. For Phase 2 - a minimum of one-half of the research and/or analytical effort must be performed by the awardee.

Unsolicited proposals or proposals not responding to stated topics or subtopics are not eligible for SBIR awards.

Phase 2 proposals may be submitted only by Phase 1 awardees.

1.04 Contact with NIST

In the interest of competitive fairness, all oral or written communication with NIST concerning a specific technical topic or subtopic during the open solicitation period is prohibited - with the exception of the public discussion group located at http://www.nist.gov/sbir. Discussion group questions will be routed to the appropriate person for a response. All questions and responses will be publicly, though anonymously, posted on the discussion group web site.

Potential awardees may not participate in the selection of any topic or subtopic nor in the review of proposals. All offerors, including, Guest Researchers, contractors, Cooperative research and Development Agreement (CRADA) partners and others working with NIST may only submit a proposal if they:

Had no role in suggesting, developing, or reviewing the subtopic; and

Have not been the recipient of any information on the subtopic not available in the solicitation or other public means; and

Have not received any assistance from DOC in preparing the proposal (including any 'informal' reviews) prior to submission.

An Agency may not enter into, or continue an existing CRADA with an awardee on the subtopic of the award.

Requests for general information on the NIST SBIR program may be addressed to:

SBIR Program
100 Bureau Drive, Stop 2200
Gaithersburg, MD 20899-2200
Telephone: (301) 975-3085, Fax: (301) 548-0624
email: sbir@nist.gov

For information on contractual issues contact:

Susan Brinkman
Acquisitions and Logistics Division
Telephone: (301) 975-8007. Fax: (301) 975-8884
email: susan.brinkman@nist.gov

2.0 DEFINITIONS

2.01 Commercialization

This is locating or developing markets and producing and delivering products for sale (whether by the originating party or by others). As used here, commercialization includes both Government and private sector markets.

2.02 Essentially Equivalent Work

This occurs when (1) substantially the same research is proposed for funding in more than one contract proposal or grant application submitted to the same Federal agency; (2) substantially the same research is submitted to two or more different Federal agencies for review and funding consideration; or (3) a specific research objective and the research design for accomplishing an objective are the same or closely related in two or more proposals or awards, regardless of the funding source.

2.03 Feasibility

The extent to which a project may be done practically and successfully.

2.04 Funding Agreement.

Any contract, grant, or cooperative agreement entered into between any Federal agency and any SBC for the performance of experimental, developmental, or research work, including products or services, funded in whole or in part by the Federal Government.

NIST will utilize contracts as the funding agreement for its SBIR awards.

2.05 Joint Venture

An association of persons or concerns with interests in any degree or proportion by way of contract, express or implied, consorting to engage in and carry out a single specific business venture for joint profit, for which purpose they combine their efforts, property, money, skill, or knowledge, but not on a continuing or permanent basis for conducting business generally. A joint venture is viewed as a business entity in determining power to control its management and is eligible under the SBIR and STTR Programs provided that the entity created qualifies as a "small business concern" as defined in herein.

2.06 Primary Employment

Primary employment means that more than one half of the principal investigator's time is spent in the employ of the small business concern. This requirement extends also to “leased” employees serving as the principal investigator. Primary employment with a small business concern precludes full time employment at another organization.

2.07 Research or Research and Development

Any activity that is (a) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (b) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (c) a systematic application of knowledge toward the production of useful materials, devices, services, or methods, and includes design, development, and improvement of prototypes and new processes to meet specific requirements.

In general, the NIST SBIR program will fund Phase 1 and 2 proposals with objectives that can be defined by (b) and (c) above.

2.08 SBIR Technical Data

All data generated during the performance of an SBIR award.

2.09 SBIR Technical Data Rights

The rights an small business concern (SBC) obtains in data generated during the performance of any SBIR Phase 1, Phase 2, or Phase 3 award that an awardee delivers to the Government during or upon completion of a Federally-funded project, and to which the Government receives a license.

2.10 Small Business Concern (SBC)

A small business concern (SBC) is one that, at the time of award for Phase 1 and Phase 2:

(a) is organized for profit, with a place of business located in the United States, which operates primarily within the United States or which makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor;
(b) is in the legal form of an individual proprietorship, partnership, limited liability company, corporation, joint venture, association, trust or cooperative, except that where the form is a joint venture, there can be no more than 49 percent participation by foreign business entities in the joint venture;
(c) is at least 51 percent owned and controlled by one or more individuals* who are citizens of, or permanent resident aliens in, the United States, except in the case of a joint venture, where each entity to the venture must be 51 percent owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States; and
(d) has, including its affiliates, not more than 500 employees.

*As of the opening of this Solicitation, the U.S. Small Business Administration (SBA) proposed and is in the process of adopting a revision of its small business size regulations to allow a small business that is owned and controlled by another business concern to be eligible for SBIR funding agreements. The proposed rule does not change the size standard requiring that an eligible small business concern, with its affiliates, have no more than 500 employees. The rule proposes to modify the small business eligibility requirements so that the SBIR awardee must meet one of the two following additional criteria: It must be a for-profit business concern that is at least 51% owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States (as the regulations currently require); **or** it must be a for-profit business concern that is 100% owned and controlled by another for-profit business concern that is itself at least 51% owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States. SBIR awards issued on or after the effective date for the new rule will benefit from the change.

2.11 Socially and Economically Disadvantaged Small Business Concern

Is one that is:

(a) at least 51 percent owned by (1) an American Indian tribe or a native Hawaiian organization, or (2) one or more socially and economically disadvantaged individuals, and
(b) controlled by one or more such individuals in its management and daily business operations.

A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent

Asian Americans, or any other individual found to be socially and economically disadvantaged by the Small Business Administration (SBA) pursuant to Section 8(a) of the Small Business Act, 15 US Code (U.S.C.) 637(a). See 13 CFR Part 124 -- 8(A) Business Development/Small Disadvantaged Business Status Determinations, §§124.103 (Who is socially disadvantaged?) and 124.104 (Who is economically disadvantaged?).

2.12 Subcontract

This is any agreement, other than one involving an employer-employee relationship, entered into under a Federal Government funding agreement, calling for supplies or services required solely for the performance of the original funding agreement.

2.13 Women-Owned Small Business

A small business that is at least 51 percent owned by a woman or women who also control (meaning to exercise the power to make policy decisions) and operate (meaning being actively involved in the day-to-day management) the small business concern.

3.0 PROPOSAL PREPARATION GUIDELINES

3.01 Proposal Requirements

NIST reserves the right to not submit to technical review any proposal which it finds to have insufficient scientific and technical information, or one which fails to comply with the administrative procedures as outlined on the Checklist of Requirements in Section 8.04. Proposals that do not successfully pass the screening criteria given in Section 4.02 will be returned to the offeror without consideration.

The objective is to provide sufficient information to demonstrate that the proposed work represents a sound approach to the investigation of an important scientific or engineering innovation worthy of support. **The proposal must meet all the requirements of the subtopic in Section 9 to which it applies**.

A proposal must be self-contained and written with all the care and thoroughness of a scientific paper submitted for publication. It should indicate a thorough knowledge of the current status of research in the subtopic area addressed by the proposal. Each proposal should be checked carefully by the offeror to ensure inclusion of all essential material needed for a complete evaluation. The proposal will be peer reviewed as a scientific paper. All units of measurement should be in the metric system.

The proposal must not only be responsive to the specific NIST program interests described in Section 9 of the solicitation, but also serve as the basis for technological innovation leading to new commercial products, processes, or services that benefit the public. An organization may submit different proposals on different subtopics or different proposals on the same subtopic under this solicitation. When the proposed innovation applies to more than one subtopic, the offeror must choose that subtopic which is most relevant to the offeror's technical concept.

Proposals principally for the commercialization of proven concepts or for market research must not be submitted for Phase 1 funding, since such efforts are considered the responsibility of the private sector.

The proposal should be direct, concise, and informative. Promotional and other material not related to the project shall be omitted. The complete proposal application must contain four copies of the following:

(a) Cover Sheet
(b) Project Summary
(c) Technical Content
(d) Proposed Budget

All signatures in each of the four copies MUST be ORIGINAL, i.e. no photocopies of signatures will be accepted.

3.02 Phase 1 Proposal Limitations

Page length must be **no more than 25 pages**. Each page is to be consecutively numbered, including the cover sheet (2 pages count as one), project summary, main text, references, resumes, any other enclosures or attachments, and the proposal summary budget. The only exception to the page count limitation are those pages necessary to comply with the itemization of prior SBIR phase 2 awards, per Section 3.03.03.02.

Paper size used for the submission must be 21.6 cm X 27.9 cm (8 ½" X 11"). Print size used for the submission must be easy to read with a fixed pitch font of 12 or fewer characters per inch or proportionally spaced font of point size 10 or larger with no more than 6 lines per inch.

Supplementary material, revisions, substitutions, audio or video tapes, or computer floppy disks will **not** be accepted.

The original and all copies of each proposal should be mailed in one package.

Proposals not meeting these requirements will be returned without review.

3.03 Instructions for Phase 1 Proposal Submission Forms and Technical Content

Instructions for completing each of the three required forms in contained in this section as well as the format required for the Technical Content section. A complete proposal application must include four copies of each of the following: Cover Sheet, Project Summary, Technical Content, and Proposed Budget. Any applications received missing any of these required items will be returned without consideration.

3.03.01 Cover Sheet

Complete all items in Cover Sheet and use as page 1 of the proposal. **NO OTHER COVER WILL BE ACCEPTED.** Photocopies are permitted, though signatures must be original.

No awards shall be made under this solicitation to small business concerns without TIN or DUNS numbers.

The TIN may be used by the Government to collect and report on any delinquent amounts arising out of the offeror's relationship with the Government (31 U.S.C. 7701(c)(3)). If the resulting contract is subject to the payment reporting requirements described in FAR 4.904, the TIN provided hereunder may be matched with IRS records to verify the accuracy of the offeror's TIN.

The DUNS number is a nine-digit number assigned by Dun and Bradstreet Information Services. If the offeror does not have a DUNS number, it should contact Dun and Bradstreet directly to obtain one. A DUNS number will be provided immediately by telephone at no charge to the offeror. For information on obtaining a DUNS number, the offeror, if located within the United States, should call Dun and Bradstreet at 1-800-333-0505. The offeror should be prepared to provide information such as: Company name, address, and telephone number, Line of business, Chief executive officer/key manager, Date the company was started, Number of people employed by the company, Company affiliation.

Offerors located outside the United States may obtain the location and phone number of the local Dun and Bradstreet Information Services office from the Internet home page at http://sbs.dnb.com. If an offeror is unable to locate a local service center, it may send an e-mail to Dun and Bradstreet at globalinfo@mail.dnb.com.

3.03.02 Project Summary

Complete all sections "Project Summary" as page 2 of your proposal. The technical abstract should include a brief description of the problem or opportunity, the innovation, project objectives, and technical approach. Keywords should be chosen to describe the proposed work both generally and specifically. In summarizing anticipated results, include technical implications of the approach and the potential commercial applications of the research. **The Project Summary of proposals that receive an award will be published by NIST and, therefore, must not contain proprietary information.**

3.03.03 Technical Content

Beginning on **page 3 of the proposal**, include the following items with headings as shown:

(a) **Identification and Significance of the Problem or Opportunity.** Make a clear statement of the specific research problem or opportunity addressed, its innovativeness, commercial potential, and why it is important. Show how it applies to a specific subtopic in Section 9.

(b) **Phase 1 Technical Objectives.** State the specific objectives of the Phase 1 effort, including the technical questions it will try to answer, to determine the feasibility of the proposed approach.

(c) **Phase 1 Work Plan.** Include a detailed description of the Phase 1 R&D plan. The plan should indicate what will be done, where it will be done, and how the R&D will be carried out. The methods planned to achieve each objective or task should be discussed in detail. This section should be at least one-third of the proposal. **NIST technical support or assistance may be available to awardees in the**

conduct of the research only if specifically provided for in the subtopic description. NIST may not enter into, nor continue, a CRADA with an awardee on the subtopic of the award.

(d) **Related Research or R&D.** Describe research or R&D that is directly related to the proposal, including any conducted by the principal investigator or by the offeror's firm. Describe how it relates to the proposed effort, and describe any planned coordination with outside sources. The purpose of this section is to persuade reviewers of the offeror's awareness of recent developments in the specific topic area.

(e) **Key Personnel and Bibliography of Related Work.** Identify key personnel involved in Phase 1, including their related education, experience, and publications. Where resumes are extensive, summaries that focus on the most relevant experience and publications are suggested. List all other commitments that key personnel have during the proposed period of contract performance.

(f) **Relationship with Future R&D.** Discuss the significance of the Phase 1 effort in providing a foundation for the Phase 2 R&D effort. Also state the anticipated results of the proposed approach, if Phases 1 and 2 of the project are successful.

(g) **Facilities and Equipment.** The conduct of advanced research may require the use of sophisticated instrumentation or computer facilities. The offeror should provide a detailed description of the availability and location of the facilities and equipment necessary to carry out Phase 1. **NIST facilities and/or equipment may be available for use by awardees only if specifically provided for in the subtopic description.**

(h) **Consultants and Subcontracts.** The purpose of this section is to convince NIST that:

(1) research assistance from outside the firm materially benefits the proposed effort, and
(2) arrangements for such assistance are in place at the time the proposal is submitted.

Outside involvement in the project is encouraged where it strengthens the conduct of the research. Outside involvement is not a requirement of this solicitation. Outside involvement is limited to no more than 1/3 of the research and/or analytical effort, per section 1.03.

1. Consultant - A person outside the firm, named in the proposal as contributing to the research, must provide a signed statement confirming his/her availability, role in the project, and agreed consulting rate for participation in the project. This statement is part of the page count.

2. Subcontract - Similarly, where a subcontract is involved in the research, the subcontracting institution must furnish a letter signed by an appropriate official describing the programmatic arrangements and confirming its agreed participation in the research, with its proposed budget for this participation. This letter is part of the page count.

No individual or entity may serve as a consultant or subcontractor if they:
Had any role in suggesting, developing, or reviewing the subtopic; or
Have been the recipient of any information on the subtopic not available to the public.

(i) **Potential Commercial Application and Follow-on Funding Commitment.** Describe in detail the commercial potential of the proposed research, how commercialization would be pursued and potential use by the Federal Government.

(j) **Cooperative Research and Development Agreements (CRADA).** State if the applicant is a former or current CRADA partner with NIST, or with any other Federal agency, naming the agency, title of the CRADA, and any relationship with the proposed work. An Agency may not enter into, nor continue, a CRADA with an awardee on the subtopic of the award.

(k) **Guest Researcher.** State if the applicant is a guest researcher at NIST, naming the sponsoring laboratory.

(l) **Cost Sharing.** Cost participation could serve the mutual interest of NIST and certain SBIR contractors by helping to assure the efficient use of available resources. Except where required by other statutes, NIST does not encourage or require cost sharing on Phase 1 projects, nor will cost sharing be a consideration in evaluation of Phase 1 proposals.

3.03.03.01 Similar Proposals or Awards

WARNING - While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous Federal program solicitations, it is unlawful to enter into funding agreements requiring essentially equivalent work. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award. If an applicant elects to submit identical proposals or proposals containing a significant amount of essentially equivalent work under other Federal program solicitations, a statement must be included in each such proposal indicating:

(i) The name and address of the agencies to which proposals were submitted or from which awards were received.
(ii) Date of proposal submission or date of award.
(iii) Title, number, and date of solicitations under which proposals were submitted or awards received.
(iv) The specific applicable research topics for each proposal submitted or award received.
(v) Titles of research projects.
(vi) Name and title of principal investigator or project manager for each proposal submitted or award received.

If no equivalent proposal is under consideration or equivalent award received, a statement to that effect must be included in this section of the technical content area of the proposal and certified within the Cover Sheet.

3.03.03.02 Prior SBIR Phase 2 Awards

If the small business concern has received more than 15 Phase 2 awards in the prior 5 fiscal years, it must submit in its Phase 1 proposal: name of the awarding agency; date of award; funding agreement number; amount of award; topic or subtopic title; follow-on agreement amount; source and date of commitment; and current commercialization status for each Phase 2 award. **This required information shall not be part of the page count limitation.**

NOTE: The Small Business Administration is mandated to establish an SBIR awardee database containing demographic, technical, outcome and output information on all SBIR awards. The database is still being developed as of the date of release of this solicitation. When it becomes available, all NIST SBIR awardees will be required to supply the required data in a timely fashion.

3.03.04 Proposed Budget

SBA Policy requires that NIST not issue SBIR awards that include provisions for subcontracting any portion of the contract back to the originating agency.

For Phase 1, a minimum of two-thirds of the research and/or analytical effort must be performed by the proposing small business concern. For Phase 2 a minimum of one-half of the research and/or analytical effort must be performed by the proposing small business concern.

Complete the Proposed Budget for the Phase 1 effort, and include it as the last page of the proposal. Some items of this form may not apply. Enough information should be provided to allow NIST to understand how the offeror plans to use the requested funds if the award is made. A complete cost breakdown should be provided giving labor rates, proposed number of hours, overhead, G&A, and profit. A reasonable profit will be allowed.

The offeror is to submit a cost estimate with detailed information for each Line Item, consistent with the offeror's cost accounting system. This does not eliminate the need to fully document and justify the amounts requested in each category. Such documentation should be contained, as appropriate, within the proposal technical content.

Lines A and B, Labor. List the key personnel and consultants by name and function or role in the project. Other direct personnel need not be named, but their role, such as “technician,” and total hours should be entered. Personnel whose costs are indirect (eg. administrative personnel) should be included in Line D. Fringe benefits can be listed for each employee in the space provided, or they may be included within the indirect costs in Line G. The PI must be employed by the small business concern at the time of contract award and during the period of performance of the research effort. Additionally, more than half of the PI's time must be spent with the small business firm during the contract performance.

Line C, Equipment. List items costing over $5,000 and exceeding 1 year of useful life. Lesser items may be shown in Line D. Indicate if equipment is to be purchased or leased. Where equipment is to be purchased or leased, list each individual item with the corresponding cost. The inclusion of equipment will be carefully reviewed relative to need and appropriateness for the research proposed.

Line D, Other Direct Costs. The materials and supplies required for the project must be identified. There is also a need to specify type, quantity, unit cost, and total estimated cost of these materials and supplies. List all other direct costs that are not described above (i.e. consultants, subcontractor, travel, and equipment purchases). Each of the above needs a detailed explanation and elaboration of its relation to the project. Use a “Budget Explanation Page” for entries requiring an explanation.

Line E, Travel. Itemize by destination, purpose, period and cost for both staff and consultants. Budgets including travel funds must be justified and related to the needs of the project. Inclusion of travel expenses will be carefully reviewed relative to need and appropriateness for the research proposed. Foreign travel is not an appropriate expense.

Line F, Total Direct Costs. Enter the sum of Lines A through E.

Line G, Indirect Costs. Cite your established Overhead (OH) and General and Administrative (G&A) rate, if any. Otherwise include all indirect costs (eg. facilities, shared equipment, utilities, property taxes, administrative staff) for the period of the project.

Line H, Total Costs. Enter the total amount of the proposed project, the sum of Lines F and G.

Line I, Profit. The small business may request a reasonable profit.

Line J, Total Amount of this request. Enter the sum of Lines H and I. This amount must equal the amount entered in the Cover Sheet Form.

Line K, Corporate/Business Authorized Representative. A signature of someone with the authority to commit the company must be given.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.01 Introduction

All Phase 1 and 2 proposals will be evaluated and judged on a competitive basis. Proposals will be initially screened to determine responsiveness. Proposals passing this initial screening will be technically evaluated by engineers or scientists to determine the most promising technical and scientific approaches. Each proposal will be judged on its own merit. The Agency is under no obligation to fund any proposal or any specific number of proposals in a given topic. It also may elect to fund several or none of the proposed approaches to the same topic or subtopic

4.02 Phase 1 Screening Criteria

To avoid misunderstanding, small businesses are cautioned that Phase 1 proposals not satisfying all the screening criteria shall be returned without peer review and will be eliminated from consideration for funding. Proposals may not be resubmitted (with or without revision) under this solicitation. All copies of proposals that fail the screening process will be returned to the offeror without consideration. The screening criteria are:

(a) The proposing firm must qualify as eligible according to the criteria set forth in Section 1.03.

(b) The Phase 1 proposal must meet **all** of the requirements stated in Section 3.

(c) The Phase 1 proposal must be limited to one subtopic and clearly address research for that subtopic.

(d) **Phase 1 proposal budget must not exceed $75,000,** including subcontract, indirect cost, and fee.

(e) **The project duration for the Phase 1 research must not exceed 6 months.**

(f) The proposal must contain information sufficient to be peer reviewed as research.

4.03 Phase 1 Evaluation Criteria

Phase 1 proposals that comply with the screening criteria will be rated by NIST scientists or engineers in accordance with the following criteria:

(a) The scientific and technical merit of the proposed research (25 points)

(b) Innovation, originality, and feasibility of the proposed research (25 points)

(c) Relevance and responsiveness of the proposed research to the subtopic to which it is addressed (25 points)

(d) Quality and/or adequacy of facilities, equipment, personnel described in the proposal (15 points)

(e) Quality of the proposal with respect to potential commercialization and/or Federal Procurements of the products and/or services sought by the subtopic (10 points)

Technical reviewers will base their ratings on information contained in the proposal. It cannot be assumed that reviewers are acquainted with any experiments referred to, key individuals, or the firm.

Final award decisions will be made by NIST based upon ratings assigned by reviewers and consideration of additional factors, including possible duplication of other research, the importance of the proposed research as it relates to NIST needs, and the availability of funding. NIST may elect to fund several or none of the proposals received on a given subtopic. Upon selection of a proposal for a Phase 1 award, NIST reserves the right to negotiate the amount of the award.

4.04 Phase 2 Evaluation Criteria

The Phase 2 proposal will undergo NIST and/or external peer review in accordance with the following criteria:

1. Degree to which Phase I objectives were met (25 points)
2. The scientific and technical merit of the proposed research, including innovation, originality, and feasibility (25 points)
3. Quality and/or adequacy of facilities, equipment, personnel described in the proposal (25 points)
4. Quality of the offeror and the proposal with respect to potential commercialization and/or Federal Procurements of the products and/or services sought by the subtopic. This involves some or all of the following factors, as appropriate; how well the proposal meets NIST mission/OU program needs; offeror's record of successful commercialization and/or Federal Procurement of research in the past; existence of non-SBIR Phase 2 funding commitments, existence of Phase 3 funding or partnering commitments (25 points)

4.05 Release of Proposal Review Information

After final award decisions have been announced, the technical evaluations of a proposal will be provided to the offeror with written notification of award/non-award. The identity of the reviewers will not be disclosed.

5.0 CONSIDERATIONS

5.01 Awards

NIST awards **firm-fixed-price contracts** as the type of funding agreement to successful offerors. A firm-fixed-price contract provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This contract type places upon the contractor the risk and full responsibility for all costs and resulting profit or loss. It provides maximum incentive for the contractor to control costs and perform effectively and imposes a minimum administrative burden upon both contracting parties. NIST also does not allow any advance payments to be made on its contract awards.

Contingent upon availability of funds, NIST anticipates making about 32 Phase 1 firm-fixed-price awards of no more than $75,000 each. The performance period shall be no more than 6 months beginning on the contract start date.

Phase 2 awards shall be for no more than **$300,000**. The period of performance in Phase 2 will depend upon the scope of the research, but should not exceed 24 months.

It is anticipated that approximately one-third of the Phase 1 awardees will receive Phase 2 awards, depending upon the availability of funds. To provide for an in-depth review of the Phase 1 final report and the Phase 2 proposal and commercialization plan, Phase 2 awards will be made approximately 4 months after the completion of Phase 1, contingent upon availability of funds.

This solicitation does not obligate NIST to make any awards under either Phase 1 or Phase 2. Furthermore, NIST is not responsible for any monies expended by the offeror before any award is made resulting from this solicitation.

Upon award of a funding agreement, the awardee will be required to make certain legal commitments through acceptance of numerous clauses in Phase I funding agreements. The outline that follows is illustrative of the types of clauses to which the contractor would be committed. This list is not a complete list of clauses to be included in Phase I funding agreements, and is not the specific wording of such clauses. Copies of complete terms and conditions are available upon request.

These statements are examples only and may vary depending upon the type of funding agreement used

(1) Standards of Work. Work performed under the funding agreement must conform to high professional standards.
(2) Inspection. Work performed under the funding agreement is subject to Government inspection and evaluation at all times.
(3) Examination of Records. The Comptroller General (or a duly authorized representative) must have the right to examine any pertinent records of the awardee involving transactions related to

this funding agreement.
(4) Default. The Government may terminate the funding agreement if the contractor fails to perform the work contracted.
(5) Termination for Convenience. The funding agreement may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the awardee will be compensated for work performed and for reasonable termination costs.
(6) Disputes. Any dispute concerning the funding agreement that cannot be resolved by agreement must be decided by the contracting officer with right of appeal.
(7) Contract Work Hours. The awardee may not require an employee to work more than 8 hours a day or 40 hours a week unless the employee is compensated accordingly (for example, overtime pay).
(8) Equal Opportunity. The awardee will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.
(9) Affirmative Action for Veterans. The awardee will not discriminate against any employee or application for employment because he or she is a disabled veteran or veteran of the Vietnam era.
(10) Affirmative Action for Handicapped. The awardee will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.
(11) Officials Not To Benefit. No Government official must benefit personally from the SBIR funding agreement.
(12) Covenant Against Contingent Fees. No person or agency has been employed to solicit or secure the funding agreement upon an understanding for compensation except bonafide employees or commercial agencies maintained by the awardee for the purpose of securing business.
(13) Gratuities. The funding agreement may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the award.
(14) Patent Infringement. The awardee must report each notice or claim of patent infringement based on the performance of the funding agreement.
(15) American Made Equipment and Products. When purchasing equipment or a product under the SBIR funding agreement, purchase only American-made items whenever possible.

5.02 Reports

Three copies of a final report on the Phase 1 project shall be submitted to NIST within 30 calendar days after completion of the Phase 1 research. The final report shall include a single-page project summary as the first page, identifying the purpose of the research, and giving a brief description of the research carried out, the research findings or results, and the commercial applications of the research in a final paragraph. The remainder of the report should indicate in detail the research objectives, research work carried out, results obtained, and estimates of technical feasibility.

All final reports must carry an acknowledgment on the cover page such as: "This material is based upon work supported by the National Institute of Standards and Technology (NIST) under contract, grant, or cooperative number___________. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of NIST."

5.03 Payment Schedule

The specific payment schedule (including payment amounts) for each award will be incorporated into the contract.

No advance payments will be allowed.

NIST will allow the Phase 1 award amount to be paid on a bimonthly interim basis upon delivery and acceptance of three progress reports that describe services performed, and one final payment upon delivery and acceptance of the final report. Likewise, NIST will allow the Phase 2 award amount to be paid on a semi-annually interim basis upon delivery and acceptance of four progress reports that describe services performed, and one final payment upon delivery of the final report.

5.04 Proprietary Information, Inventions, and Patents

5.04.01 Limited Rights Information and Data

Information contained in unsuccessful proposals will remain the property of the offeror. Any proposal which is funded will not be made available to the public, except for the "Project Summary" page.

The inclusion of proprietary information is discouraged unless it is necessary for the proper evaluation of the proposal.

Information contained in unsuccessful proposals will remain the property of the applicant. The Government may, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements. If proprietary information is provided by an applicant in a proposal, which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence, to the extent permitted by law. This information must be clearly marked by the applicant with the term "confidential proprietary information" and the following legend must appear on the title page of the proposal:

> "These data shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part for any purpose other than evaluation of this proposal. If a funding agreement is awarded to this applicant as a result of or in connection with the submission of these data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the funding agreement and pursuant to applicable law. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction are contained on pages ____ of this proposal."

Any other legend may be unacceptable to the Government and may constitute grounds for removing the proposal from further consideration, without assuming any liability for inadvertent disclosure. The Government will limit dissemination of such information to within official channels."

5.04.02 Copyrights

The contractor may normally establish claim to copyright any written material first produced in the performance of an SBIR contract. If a claim to copyright is made, the contractor shall affix the applicable copyright notice of 17 U.S.C. 401 or 402 and acknowledgment of Government sponsorship (including funding agreement number) to the material when delivered to the Government, as well as when the written material or data are published or deposited for registration as a published work in the US Copyright Office. For other than computer software, the contractor gives to the Government, and others acting on its behalf, a paid-up, nonexclusive, irrevocable, worldwide license to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government.

For computer software, the contractor gives to the Government a paid-up, nonexclusive, irrevocable, worldwide license for all such computer software to reproduce, prepare derivative works, and perform publicly and display publicly, by or on behalf of the Government.

5.04.03 Data Rights

Except for copyrighted data, the Government shall normally have unlimited rights in:

(a) data specifically identified in the SBIR funding agreement to be delivered without restriction;
(b) form, fit, and function data delivered under the funding agreement;
(c) data delivered under the funding agreement that constitute manuals or instructions and training material for installation, operation, or routine maintenance and repair of items, components, or processes delivered or furnished for use under the funding agreement; and
(d) all other data delivered under the funding agreement unless identified as SBIR data.

According to Federal Acquisition Regulation 52.227-20, Rights and Data - SBIR Program (March 1994), the awardee is authorized to affix the following "SBIR Rights Notice" to SBIR data delivered under the funding agreement:

SBIR RIGHTS NOTICE

These SBIR data are furnished with SBIR rights under Contract No.____________ (and subagreement _________________, if appropriate). For a period of 4 years after acceptance of all items to be delivered under this award, the Government agrees to use these data for Government purposes only, and they shall not be disclosed outside the Government (including disclosure for procurement purposes) during such period without permission of the awardee, except that, subject to the forgoing use and disclosure prohibitions, such data may be disclosed for use by support contractors. After the aforesaid 4-year period, the Government has a royalty-free license to use, and to authorize others to use on its behalf, these data for Government purposes, but is relieved of all disclosure prohibitions and assumes no liability for unauthorized use of these data by third parties. This Notice shall be affixed to any reproductions of these data, in whole or in part.

(END OF NOTICE)

The Government's sole obligation with respect to any properly identified SBIR data shall be as set forth in the paragraph above.

5.04.04 Patents

Small business concerns normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty free license for Federal Government use, reserves the right to require the patent holder to license others in certain circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35U.S.C. 205, the Government will not make public any information disclosing a Government supported invention for a minimum 4-year period (that may be extended by subsequent SBIR funding agreements) to allow the awardee a reasonable time to pursue a patent**.**

5.04.05 Invention Reporting

SBIR awardees must report inventions to the NIST SBIR Program within 2 months of the inventor's report to the awardee. The reporting of inventions may be accomplished by submitting paper documentation, including fax.

5.05 Additional Information

(1) This program solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR funding agreement, the terms of the funding agreement are controlling.

(2) Before award of an SBIR funding agreement, the Government may request the applicant to submit certain organizational, management, personnel, and financial information to assure responsibility of the applicant.

(3) The Government is not responsible for any monies expended by the applicant before award of any funding agreement.

(4) This program solicitation is not an offer by the Government and does not obligate the Government to make any specific number of awards. Also, awards under the SBIR Program are contingent upon the availability of funds.

(5) The SBIR Program is not a substitute for existing unsolicited proposal mechanisms. Unsolicited proposals must not be accepted under the SBIR Program in either Phase 1 or Phase 2.

(6) If an award is made pursuant to a proposal submitted under this SBIR Program solicitation, a representative of the contractor will be required to certify that the concern has not previously been, nor is currently being, paid for essentially equivalent work by any Federal agency.

(7) The responsibility for the performance of the principal investigator, and other employees or consultants who carry out the proposed work, lies with the management of the organization receiving an award.

(8) Cost-sharing is permitted for proposals under this program solicitation; however, cost-sharing is not required. Cost-sharing will not be an evaluation factor in consideration of your Phase I proposal.

5.06 Research Projects with Human Subjects, Human Tissue, Data or Recordings Involving Human Subjects

Any proposal that includes research involving human subjects, human tissue, data or recordings involving human subjects must meet the requirements of the Common Rule for the Protection of Human Subjects, codified for the Department of Commerce at 15 CFR Part 27. In addition, any proposal that includes such research on these topics must be in compliance with any statutory requirements imposed upon NIH and other federal agencies regarding these topics, all regulatory policies and guidance adopted by NIH, FDA, and other federal agencies on these topics, and all Presidential statements of policy on these topics. Any questions regarding these requirements should be addressed to Melissa Lieberman at (301) 975-4783 or melissa.lieberman@nist.gov.

IRB Education Documentation. A signed and dated letter is required from the Organizational Official who is authorized to enter into commitments on behalf of the organization documenting that appropriate IRB education has been received by the Organizational Official, the IRB Coordinator or such person that coordinates the IRB documents and materials if such a person exists, the IRB Chairperson, all IRB members and all key personnel associated with the proposal. The NIST requirement of documentation of education is consistent with NIH notice OD-00-039 (June 5, 2000). Although NIST will not endorse an educational curriculum, there are several curricula that are available to organizations and investigators which may be found at: http://grants.nih.gov/grants/guide/notice-files/NOT-OD-00-039.html.

5.07 Research Projects Involving Vertebrate Animals

Any proposal that includes research involving vertebrate animals (including fish) must be in compliance with the National Research Council's "Guide for the Care and Use of Laboratory Animals" which can be obtained from National Academy Press, 2101 Constitution Avenue, NW, Washington, D.C. 20055. In addition, such proposals must meet the requirements of the Animal Welfare Act (7 U.S.C. 2131 et seq.), 9 CFR Parts 1, 2, and 3, and if appropriate, 21 CFR Part 58. These regulations do not apply to proposed research using pre-existing images of animals or to research plans that **do not** include live animals that are being cared for, euthanased, or used by the project participants to accomplish research goals, teaching, or testing. These regulations also do not apply to obtaining animal materials from commercial processors of animal products or to animal cell lines or tissues from tissue banks.

6.0 SUBMISSION OF PROPOSALS

6.01 Deadline for Proposals

Deadline for Phase 1 proposal receipt (4 copies) at the address below is **3:00 pm** on **January 30, 2004 at the Contracts Office address below. NIST does not accept electronic submission of proposals.**

All Offerors should expect delay in delivery due to added security at NIST. It is the responsibility of the Offeror to make sure delivery is made on time.

Because of the heightened security at NIST, FED-EX, UPS or similar-type service is the preferred method of delivery of proposals.

If proposals are to be hand delivered, delivery must be made on the actual deadline date and a 24-hour notice must be made to the NIST Contracts Office prior to delivery. All Offerors must notify Susan Brinkman at 301-975-8007, or Romena Moy at 301-975-4999. The name of the individual or courier company making the delivery must be included in the notification.

NIST assumes no responsibility for evaluating proposals received after the stated deadline or that do not adhere to the other requirements of this solicitation (see checklist at back of booklet). Such proposals **will** be returned to the offeror without review.

Federal Acquisition Regulation (FAR 52 215-1) regarding late proposals shall apply.

Letters of instruction will be sent to those eligible to submit Phase 2 proposals. The Phase 2 proposals are due at about the same time as Phase 1 final reports - 7 months after commencement of the Phase 1 contract.

Offerors are cautioned to be careful of unforeseen delays, which can cause late arrival of proposals at NIST, resulting in them not being included in the evaluation procedures. No information on the status of proposals under scientific/technical evaluation will be available until formal notification is made.

6.02 Proposal Submission

Submission of Proposal Packages as defined in section 3.3 should be sent in **4 copies** to:

National Institute of Standards and Technology
Acquisitions and Logistics Division
Attn: Susan Brinkman, NIST–04-SBIR
100 Bureau Drive STOP 3571
Building 301, Room B129
Gaithersburg, MD 20899-3571

Phone Number: (301) 975-8007

Photocopies will be accepted. All signatures in each of the four copies MUST be ORIGINAL, i.e no photocopies of signatures will be accepted.

Acknowledgment of receipt of a proposal by NIST will be made. All correspondence relating to proposals must cite the specific **proposal number** identified on the acknowledgment.

(a) **Packaging--Secure packaging is mandatory. NIST cannot process proposals damaged in transit. All 4 copies of the proposal must be sent in the same package. Do not send separate "information copies," or several packages containing parts of a single proposal, or two packages of 4 copies of the same proposal**
(b) Bindings--**Do not use special bindings or covers.** Staple the pages in the upper left hand corner of each proposal. Separation or loss of proposal pages cannot be the responsibility of NIST.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

Background information related to the NIST research programs referenced within the subtopics may be found within the NIST website at: www.nist.gov. Wherever possible, reference citations are provided within the individual subtopics.

8.0 SUBMISSION FORMS AND CERTIFICATIONS

8.01 Cover Sheet **(2 pages)**

8.02 Project Summary

8.03 Proposed Budget

8.04 Checklist of Requirements

Please review this checklist carefully to assure that your proposal meets the NIST requirements. All signatures in the above forms MUST be original. **No photocopies of signatures will be accepted.** Failure to meet these screening requirements will result in your proposal being returned without consideration. **Four copies of the proposal must be received by 3:00p.m. EST January 30, 2004.**

1. The **COVER SHEET** (both pages combined) has been completed and is **PAGE 1** of the proposal.
2. The **PROJECT SUMMARY** has been completed and is **PAGE 2** of the proposal.
3. The **TECHNICAL CONTENT** of the proposal **begins on PAGE 3** and includes the items identified in **SECTION 3.3.3** of the solicitation. The technical content section of the proposal is limited to 22 pages in length.
4. The **SBIR PROPOSAL PROPOSED BUDGET** has been completed and is the **LAST PAGE** of the proposal.
5. The proposal is **25 PAGES OR LESS** in length.
6. The proposal is limited to only **ONE** of the subtopics in Section 9.
7. The proposal budget is for **$75,000 or LESS**. No more than one-third of the budget goes to consultants and/or subcontractors.
8. The abstract contains **no proprietary information** and does **not exceed** space provided on the Project Summary.
9. The proposal contains only pages of 21.6cm X 27.9cm size (8 ½" X 11").
10. The proposal contains **an easy-to-read font (fixed pitch of 12 or fewer characters per inch or proportional font of point size 10 or larger) with no more than 6 lines per inch,** except as a legend on reduced drawings, but not tables.
11. The P.I. is employed by the company.

NOTE: Offerors are cautioned to be careful of unforeseen delays that can cause late arrival of proposals, with the result that they **WILL** be returned without evaluation.

9.0 TOPIC AREAS

9.01 ADVANCED BIOLOGICAL AND CHEMICAL SENSING

9.01.01 Subtopic: CW Terahertz Sources

Broadly-tunable narrow-band (<10 MHz, ~10 uWatts) cw THz-laser source is desired of the spectral range from 2 cm-1 to 250 cm-1 for application to the spectroscopy of biological samples. The increasing need for instrumentation sensitive to the conformational structures of polypeptides, proteins, polysaccharides and DNA has promoted significant growth in techniques based in the THz region. This light can, for instance, be generated by low-temperature grown GaAs photomixers. Powers up to 1-5 μWatts are now possible using current antenna designs. However, material properties such as poor heat conductivity currently limit the performance of LT-GaAs devices. Other materials such as ErAs:GaAs offer great promise to overcome these limitations. NIST seeks proposals for innovative methods for efficient generation of cw THz light for conformational studies of biological systems. A component of the Phase 1 part of this program will consist of delivering a prototype for testing and evaluation by NIST personnel.

9.02 ANALYTICAL METHODS

9.02.01 Subtopic: Analytical Wavelength Dispersive X-ray Spectrometer With Peak Imaging

NIST has need of a peak-imaging wavelength dispersive (i.e., diffraction-based) x-ray spectrometer (PI-WDS) for elemental analysis with electron and photon excitation. Peak imaging means that the spectrometer will form a dispersed image of the x-ray peak that covers a sufficient photon energy range to completely span the characteristic peak and a range of the spectral background above and below the peak. This PI-WDS will permit simultaneous measurement of the complete diffracted peak structure and accommodate accurate removal of background under the peak by interpolation of the background channels on either side of the peak. For example, with an LiF diffractor that has a spectral resolution (defined as the full peak width at half the maximum intensity, FWHM) of 15 eV at 6400 eV (FeKa), the PI-WDS will cover a photon energy range of at least 40 eV. The actual width of the x-ray energy band that is simultaneously passed through the spectrometer will depend upon the diffractor chosen. It is desired that the PI-WDS will have an energy range from 100 eV to 10,000 eV with a selection of WDS diffractors (e.g., LiF, pentaerythritol (PET), thallium acid phthalate (TAP), and synthetic multilayer structures such as Mo-C and W-C). The output of the PI-WDS will be an ASCII file of counts per channel versus channel number. At least 128 channels will span the energy range of the PI-WDS. The PI-WDS will be controlled by a computer that will permit stepping from one specified peak position to another, dwell for a specified time, and digital recording of the peak image. A prototype detector will be delivered to NIST and tested during Phase 2.

NIST will be willing to collaborate with the awardee.

9.02.02 Subtopic: High-Accuracy, High-Stability, High-Pressure Transducers

High-accuracy, high-stability pressure transducers play a critical role in NIST primary standards for pressures to 280 MPa. They serve as check standards and transfer standards, are critical elements for pressure controllers, and are essential for conducting important comparisons of international measurement standards. Their applications are not limited to NIST and other national measurement institutes or calibration laboratories, but span broad industries including the aerospace, automotive, defense, and microelectronics sectors. Transducers based on quartz resonant gages (QRG) have shown excellent short- and long-term calibration stability (0.001 %/day, 0.01%/year) and excellent pressure resolution (0.0001 %), but their highest full-scale range is 280 MPa. The pressure region from 280 MPa to 500 MPa is important both for international measurement standards and industrial applications, and no transducers currently exist with the characteristics similar to QRGs at the lower pressure. We wish to promote the development of new transducers that function from 280 MPa to 500 MPa and beyond, with similar levels of calibration stability and resolution as QRGs. Other favorable attributes would be mechanical robustness and overpressure protection, fast response, and insensitivity to geometrical orientation. It is expected that prototype devices, developed under Phase 2 funding, would be made available for evaluation at NIST.

References:

Miiller, A. P., "Measurement performance of high-accuracy low-pressure transducers," Metrologia, 36, 617-621, 1999.

Olson, D.A., and Kobata, T., "Automating the calibration of two piston gage pressure balances," Proceedings of the 2002 NCSL International Workshop and Symposium, August 2002.

9.02.03 Subtopic: Software Development on High Speed Impact of Multi-layered Materials

Modern coating technologies such as CVD, PVD and laser-assisted ion sputtering techniques have enabled successful fabrication of multi-layered materials or devices at the nanometer size scale. These products have potential applications in computer and magnetic data storage industry such as hard disk drives. The tribological performance of the multi-layered devices is of major concern. In the case of hard disk drives, the consequence of sliding contact due to the collision of the slider at the head/disk interface during the high speed rotating service conditions needs to be ascertained.

Proposals are being solicited that will develop software packages to simulate the real time sliding contact event between nanoasperity and the smooth disk surface under high speed (in the order of 10 m/s of linear velocity) impact conditions. Both analytical and numerical approaches are encouraged. The input include: asperity size, impact velocity, properties of layered devices and geometry including layer thicknesses and, of course, contact pair characteristics (such as friction coefficient). For the given input, the software package will simulate the impact event and predicts the aftermath as a consequence of the severe impact. We are interested in finding the field solutions of stress, deformation and damage zone underneath the sliding plane, as well as time-history solutions of asperity penetration, energy transfer, heat generation, contact forces, deformation zone size and the solutions of contact duration and contact zone size. The work should be useful in assessing the service life of those devices for device designers and manufacturers.

Software code (both source and executable) will be a deliverable for the eventual Phase 2 project. NIST is willing to collaborate with the company and provide access to NIST capabilities when necessary.

9.02.04 Subtopic: Adiabatic Demagnetization Refrigerator for X-ray Microanalysis

NIST is a world leader in the development of superconducting transition edge sensors and SQUID amplifiers for ultra-high-resolution x-ray spectroscopy for the semiconductor industry. The ability of these systems to detect photons with high energy resolution and near-unity quantum efficiency enables applications such as the identification of nanoscale contaminant particles and the elemental analysis of thin film structures in integrated circuits. Widespread use of these microanalysis systems will be facilitated by the development of a new generation of Adiabatic Demagnetization Refrigerators. (ADR's). ADR's are used to cool the sensors to temperatures below 100 mK and, for commercial application, must be compact, reliable, and efficient.

Proposals are solicited for development of an ADR capable of maintaining a temperature less than 100 mK for a minimum of 48 hours without recycling. In addition, the system must demonstrate a suspension system lifetime of greater than 50 cooldown cycles and maintain a field at the sensor of less than 0.1 mT without the use of ferromagnetic shields. Other innovations to further reduce refrigerator size and weight are encouraged. NIST will provide designs for and results of studies on non-filamentary suspension systems and self shielded magnets. The deliverables under Phase II of this effort would be two prototype refrigerators for testing by NIST. NIST would test and evaluate the prototype systems and provide results of this evaluation to the company. It is anticipated that a successful refrigerator would be immediately marketable to the x-ray microanalysis market and to other users of very low temperature refrigerators.

Reference:

High-Energy Resolution Microcalorimeter Spectrometer For X-Ray Microanalysis, D. A. Wollman, K. D. Irwin, G. C. Hilton, L. L. Dulcie, D. E. Newbury and J. M. Martinis. Journal of Microscopy 188(3) 196-223, December 3, 1997.

9.02.05 Subtopic: Microcalorimeter Instrumentation for X-ray Microanalysis

NIST is a world leader in the development of superconducting transition-edge sensors and SQUID amplifiers for ultra-high-resolution x-ray spectroscopy for the semiconductor industry [1]. The ability of these systems to detect photons with high energy resolution and near-unity quantum efficiency enables applications such as the identification of nanoscale contaminant particles and the elemental analysis of thin film structures in integrated circuits.

Proposals are solicited for x-ray microcalorimeters and supporting electronics, hardware, and software. Development of x-ray microcalorimeters and optimized read-out Superconducting Quantum Interference Devices (SQUIDs) is required. Development of some items on the following list is desirable: room temperature SQUID read-out electronics, appropriate electrical interconnects, infrared blocking filters, and a cold-finger for inserting microcalorimeters into an analytical instrument. Other innovations to improve system stability and ease-of-use are encouraged. NIST will provide designs for the SQUID amplifiers, filters, and cold-finger presently in use on a microcalorimeter instrument at the Boulder Laboratories.

The deliverable under Phase II of this effort is a microanalysis system. NIST will test and evaluate the prototype system and provide results of this evaluation to the company. NIST will also make testing facilities available to measure the Tc of films intended for x-ray microcalorimeters. It is anticipated that the instrumentation developed in a successful effort will be immediately marketable to the x-ray analysis community.

[1] High-Energy Resolution Microcalorimeter Spectrometer For X-Ray Microanalysis, D.A. Wollman, K.D. Irwin, G.C. Hilton, L.L. Dulcie, D.E. Newbury, and J.M. Martinis. Journal of Microscopy 188(3) 196-223, December 3, 1997.

9.03 CONDITION-BASED MAINTENANCE

9.03.01 Subtopic: Software Tools for IEEE 1451-based Smart Sensor Networks

Digital communications networks promise to become ubiquitous. Applications of such network technology span the range from factories to offices, to homes, and to vehicles. Development of domain-oriented tools such as application specific, configuration, testing, deployment, and development tools has lagged behind the development of digital networks. Typically, buyers must commit to single-vendor solutions for many applications. This has limited innovation and concentrated market share in many industries. The recently approved IEEE 1451 Standard for a Smart Transducer Interface for Sensors and Actuators provides a new model for plug-and-play hardware and software. Applying this standard, users will be able to assemble 1451-compliant software and hardware modules from diverse suppliers into systems that work seamlessly in concert. Software tools, that enable the fast and efficient building of application solutions for 1451-based sensor networks and systems, are needed.

Innovative ideas may encompass methodologies, tools, applications software, and other such concepts, which reduce the time and effort needed to construct 1451-compliant applications. Expected Phase I results are the delivery of software design, architecture, or software code (preferably including source code) using modern modeling tools, that enables the fast and efficient building of application for IEEE 1451-based wired or wireless sensor network. Expected Phase II results are the delivery of prototype software tools that is suitable for commercialization and a demonstration of the utility of the tools in a number of practical and commercial applications.

The awardee would be provided, if needed, detailed information about the IEEE 1451 standards and their implementations developed at NIST. NIST will be willing to collaborate with the awardee.

9.04 HEALTHCARE AND MEDICAL PHYSICS

9.04.01 Subtopic: Thermal Imaging of Water With µK Resolution at 22°C

NIST develops and maintains national primary standards for clinical radiation absorbed dose based on measurements of the temperature rise using water calorimetry. For decades and throughout the world, National Measurement Institutes (NMIs) have relied on measurements of the resistance change in thermistors in a Wheatstone bridge. It is the only feasible means for the accurate measurement of the sub-milli-Kelvin temperature rise at room temperature. However, it is hindered by complicated heat defect and heat transport corrections. We seek an innovative non-evasive method that can compete with the existing thermistor-based technology, utilizing the exploding advances in the thermal detection and imaging field. The new technology would offer these advantages: 1. with an optical method rather than electrical, we may reduce the complexity of the heat exchange problem caused by the probe. 2. we can study the temperature change in the micrometer spatial scale and in the millisecond time scale. This approach can be used to verify the existing thermal modeling.

There are many new sensitive temperature measurement techniques, for example, fluorescence dye [1] or quantum dots, Raman thermometry, and infrared sensing that may be suitable for use in water, when coupled with fiber optics. The challenge of detecting the lower-than-noise signals may be addressed with modern electronics. The proposing party, after evaluating the state-of-the-art technologies, decides what the best approach should be. The ultimate device can be run in two modes: a low-resolution mode for temperature mapping in real time by thermal imaging for studying the water behavior under radiation, and a high resolution mode capable of 10 μK resolution at room temperature for standards work. In Phase 1, we need to have the low-resolution (1mK at RT) operation demonstrated by a working device, and a conceptual design of the high-resolution mode. This device is to be delivered to NIST. The first customers of this technology would be the NMI albeit only a handful of them in the world, but the commercial outlook lies in the medical clinics world wide where water phantom is used to simulate human tissue response to radiation. Even if the high-resolution goal is proved unattainable, determination of a thermal map in water in real time would be a valuable contribution to the world of water calorimetry.

NIST will be willing to collaborate with the awardee and provide testing and characterization.

[1] David Ross, Michael Gaitan, and Laurie E. Locascio, Temperature Measurement in Microfluidic Systems Using a Temperature-Dependent Fluorescent Dye, Anal. Chem. 2001, 73, 4117-4123.

9.05 HOMELAND SECURITY

9.05.01 Subtopic: Wireless Network Smart Sensors

Wireless network smart sensors play a very important role in homeland security and first responder (HLS-FR) applications. A smart sensor can reduce a large amount of data measured from a single sensor, a cluster of sensors, or an array of sensors to simple, human readable information for quick decision-making. Without the need to lay many long cables, these wireless sensors can be easily deployed anywhere for surveillances and to monitor environmental and hazardous conditions. Integrated with networking capability, these wireless sensors can be linked to form a wireless sensor network that can pass and exchange data among sensors and to the Internet for easy access with a common web browser. The activity of a malfunctioned or damaged sensor can be quickly taken over by the adjacent sensors. In some applications, it is important to know the location of the sensor. In some specific HLS-FR applications, it is desirable to have a wireless smart sensor that can report its location inside or outside a building, in a moving vehicle, container, or vessel with accuracy to as small as one foot. The wireless smart sensor could use the latest GPS, differential GPS, or other advanced localization techniques or technologies to identify its location. It is also very desirable to have wireless smart sensors that can be powered by energy derived from the ambient environment, thus freeing them of the need for power cables or battery changes. In addition, smart sensors with integrated self-test, built-in calibration, or self-healing capability can ensure the proper functioning of the sensors for an extended period before servicing is required.

NIST is conducting research and development work on communication and connectivity standards for smart and wireless sensors for HLS-FR applications. We are currently working with IEEE and industry to standardize wireless communication interfaces for smart sensors and seeking to establish a wireless framework for sensors. Hence, we solicit proposals for the development of ambient-powered, wireless, network, smart sensors that can detect chemical, biological, radiological, nuclear, and explosive parameters or hazards, and/or measure temperature, air flow, vibration etc. A multi-sensor smart device that can measure multiple physical phenomena and provide a single output parameter will be given a higher score in the proposal evaluation process. Proposals that include more of the capabilities described will be rated with a higher score accordingly. These wireless smart sensors should be designed for compatibility with the IEEE 1451 family of standards. It is recommended that the proposing party be thoroughly familiar with IEEE 1451. Copies of the standards can be acquired from IEEE at 1-800-678-4333.

Expected Phase 1 result is the delivery of units of wireless smart sensors with early demonstration capability including some of these characteristics: ambient-powered, wireless networking capability, localization, self-test, built-in calibration, IEEE 1451.x TEDS, etc. It is expected that a Phase 2 effort will result in the construction and demonstration of a full-function prototype suitable for commercialization.

The awardee would be provided, if needed, detailed information about the IEEE 1451 standards and their implementations developed at NIST. NIST will be willing to collaborate with the awardee.

9.05.02 Subtopic: Mobile Robot Platform for Urban Search and/or Rescue and Explosive Ordnance Disposal Applications

The NIST Reference Test Arenas for Autonomous Mobile Robots were developed for the purpose of providing mobile robotic platforms and other intelligent implementations the environment with which they can be repeatedly tested and evaluated. A robot's performance within the arenas can be quantified with the performance metric NIST and researchers from other government agencies, industry, and academia have developed. This metric has evolved considerably over several years to encourage mobile robots to excel in collaboration, autonomy, planning, knowledge representation, and perception. However, for these elements to be accurately measured and evaluated, it is imperative that the robotic system be built upon a robust mobility platform that features a variety of sensors. At present, these five elements cannot be decoupled from the mobility and sensing dependencies, which prevents researchers from isolating shortcomings in these five critical elements. Therefore, it would be beneficial to the community to have a common robotic platform which they can build upon.

Proposals are sought for a low-cost mobile robotic platform capable of negotiating structured and unstructured environments to perform urban search and rescue and/or explosive ordnance disposal tasks. The platform should be designed to be teleoperational, yet have an open architecture such that external software may be integrated to allow for autonomous functionality. Sensors should be incorporated to allow for collaboration, autonomy, planning, knowledge representation, perception, and navigation of the various environments. Modularity is also important such that additional sensors (infrared, LADAR, etc,…) and tools (grasping mechanism, blast disruptor, etc,…) may be inserted depending upon the specific task.

NIST personnel that are testing and evaluating urban search and rescue and explosive ordnance disposal robots will make the NIST Reference Test Arenas for Autonomous Mobile Robots available to the awarded company(s) to collect data from the environment and to evaluate their implementation(s). NIST personnel will also be available to offer input and suggestions. Companies receiving Phase I awards will be required to provide a synopsis of the current state-of-the-art in mobility and sensory capabilities and demonstrate a proof-of-concept of their idea that should include comparisons to other currently available technologies along with concept drawings, and projected technical specifications and costs of their idea. Companies receiving Phase II awards must deliver to NIST their developed mobile robotic system with sensors, all source code that is used regardless of whether processing is done on or off-board, and a report detailing the platform's capabilities, specifications, required parts, fabrication, assembly, and operation.

References:

Jacoff, A., Messina, E., and Evans, J. "Performance Evaluation of Autonomous Mobile Robots," Industrial Robot: An International Journal, Vol. 29 No. 3, Emerald Library, 2002.

Jacoff, A., Messina, E., Evans, J. "A Standard Test Course for Urban Search and Rescue Robots," Proceedings of the Performance Metrics for Intelligent Systems Workshop, August 2000, Gaithersburg, MD.

9.05.03 Subtopic: Millimeter-wave Multipliers for High Peak Power

NIST is actively developing millimeter-wave imaging systems for homeland security and other applications, and has developed world-leading focal-plane arrays (FPA's) of antenna-coupled detectors. Mm-wave imagers are likely to form the next generation of personnel screening systems for airports, military checkpoints, courthouses, etc. The high speed of the NIST FPA's is particularly well suited to system architectures based on pulsed, high peak power illumination. At 100 GHz, presently available solid-state (Si Impatt) oscillators offer peak power levels up to 10 W, with duty cycles of approx. 1 % (i.e. average power of 100 mW). However, no similar solid-state oscillators are available at frequencies of 200-400 GHz, and in many applications, optimal use of the NIST FPA's requires the higher frequency in order to improve the spatial resolution and standoff range of complete imaging systems.

Proposals are solicited for development of solid-state multipliers that are capable of handling powers in the range up to 10 W peak power,100 mW average power, for a fundamental source at 100 GHz. Innovative diode (varactor or varistor) design approaches to increase breakdown voltage are sought, as well as novel waveguide designs which potentially may incorporate active cooling. Waveguide output and purely solid-state devices are required. Efficiency must be greater than 20 % for each stage of doubling. 5 % bandwidth is required, but beyond that, fractional bandwidth is less important than high efficiency. In Phase I, a single-stage doubler should be demonstrated. The Phase II deliverable would be a packaged two-stage quadrupler unit designed for 100 GHz WR-10 input, with the capability to easily switch between the doubled and quadrupled signals.

9.06 INFORMATION TECHNOLOGY

9.06.01 Subtopic: Gigabit/second Random Number Generators

The NIST Quantum Information Testbed project is a demonstration platform for accomplishing quantum cryptographic key distribution at gigabit/second transmission rates. A limiting factor in this process is the generation of random numbers that constitute the key. Accordingly, NIST seeks research proposals for hardware-based random number generators capable of producing 109 random bits per second. It is envisaged that such a generator will use some random physical process, such as electrical noise in a circuit element or a quantum transition, as the basis of a random sequence. Devices that are based on deterministic algorithms are not acceptable. Phase 2 work on this subject should result in the delivery to

NIST of a prototype device that can be incorporated into the testbed. Further information on the testbed project is available at http://qubit.nist.gov/.

Though not necessary, NIST would consider working collaboratively with the awardee.

9.06.02 Subtopic: Standards-Compliance Test Equipment for Broadband Wireless Access

NIST is seeking the capability to test the compliance of broadband wireless access communications equipment to the specifications in IEEE Standard 802.16 (as amended and revised) and its associated conformance standards, including IEEE Standard 802.16/Conformance01, etc. This is arguably the most complex air interface standard yet devised, with multiple configurations to be varied dynamically and tested under a variety of simulated error conditions. Because of the complexity of the test requirements, conformance testing will be extremely difficult and expensive without innnovative automated procedures. Demand for test equipment will blossom once equipment based on the standard becomes available.

The primary need is to test subscriber stations. The key objective of this solicitation is a tool capable of interacting with subscriber stations and interrogating them for compliance to the specifications. Such a tool would, in effect, simulate an IEEE 802.16-compliant base station. The tool must be capable of testing for compliance to at least one profile in the standard (per Clause 12 of IEEE 802.16), but more would be preferable. A low-power radio-frequency interface, via transmission line or waveguide, will be appropriate at this stage.

The functioning test system should be fully controllable through a network connection to operate the test procedures. It should be capable of being interfaced to a commercial system that accepts test procedures based on software conforming to ITU-R Recommendation Z.140 ["The Tree and Tabular Combined Notation version 3 (TTCN-3): Core Language"].

The Phase 1 deliverable is a description of the proposed system, including its interfaces and a list of the system profiles to be tested, along with plans for the system's development and a study of the special equipment requirements. The Phase 2 deliverable should be a working test system and software code to drive it from a standard and commercially available interface. The test system documentation, including a description of the built-in test procedures and documentation of their use in carrying out more complex procedures, should be made available for submission to the IEEE 802.16 Working Group <http://ieee802.org/16> for use in developing standardized test procedures in TTCN code.

NIST would work directly with the company to ensure that the equipment interface is appropriate.

9.06.03 Subtopic: Safety and Privacy in Managing Credentials

With the emergence of trusted computing platforms and hardware security tokens, it is possible to securely and privately store and process information on a workstation. This capability brings to light the problem of securely exchanging identity and credential information with other entities, as well as controlling the privacy implications of their storage. The focus of this research topic is to develop technologies that will process user- and platform-related credentials and interface to outside service providers, access management systems, peer platforms, or other entities, in a way that maximizes individual privacy while allowing users to maintain long-term accounts and/or relationships with selected service providers or systems.

9.06.04 Subtopic: Device Independent Interaction Framework for Immersive Scientific Visualization

Scientific discovery in immersive visualization environments is impeded by a lack of products that support device-independent interaction techniques. We solicit tools that enable scientists to select computer hardware devices and interaction techniques that are most appropriate to their investigation, without necessitating modifications to their software to manage the particular devices, platform, and configuration selected.

Interfaces that are intuitive and natural to use allow scientists to concentrate on understanding their data without extensive training in the use of specialized devices. Devices we think could be useful include off-the-shelf commercial PC game input devices, PDA's, and Pocket PC's; however, such devices are not currently usable in immersive visualization environments. This solicitation is not limited to these devices. Other areas that might be explored include devices for gesture and/or voice-based input, as well as new inventions.

Requirements for this proposal include: (1) Software should be based on the open source immersive visualization system DIVERSE (diverse.sourceforge.org). (2) Hardware devices should be compatible with common Linux-based PC systems. (3) Software should run on all DIVERSE supported systems. (4) Intelligent or programmable user interaction devices may have their own software which is downloadable from a Linux system. (5) The system architecture should provide a high level of device independence, such that multiple physical devices can be substituted for each other to provide the same user interaction. (6) The communications between the Linux-based device driver and the immersive environment system must be based on DIVERSE networked shared memory and message passing. (7) Interaction techniques must be encapsulated as DIVERSE DSOs, allowing them to be dynamically loaded into any DIVERSE application while the application is running. (8) Hardware devices should be hot-swappable using the DIVERSE server while the DIVERSE application is running. (9) Interaction techniques should be made available to the DIVERSE desktop simulator to allow software development when the physical device is not available.

For Phase 1, deliverables should include: (1) The design of a framework that extends DIVERSE and brings a new range of hardware devices and interactive techniques to the immersive scientific visualization environment. (2) Implementation of two prototypical devices and a demonstration of their use. (3) Demonstration of device-independence within a running sample application in both a full immersive environment and the desktop environment. The ultimate goal of the project should be commercialization of products, their support, and expanding the marketplace for immersive scientific visualization. Deliverables will include source and executable codes developed. A simple implementation would be deliverable for Phase 1. The whole system would be delivered for Phase 2.

9.06.05 Subtopic: Applying Software Test Generation Methods to Large Programs

Up to 50% of the cost of software development is testing. In addition, adequately secure software can no longer depend on user testing to find security bugs. Writing tests manually is labor-intensive and misses important tests. Specification-based formal test generation methods, based on model checking [1], have been developed, but applying these methods to large programs requires several innovative solutions.

First, we need ways to semi-automatically partition and/or abstract specifications into pieces small enough to process [2]. Tests resulting from these pieces must then be merged and elaborated to form a test suite. The pieces must be sound, that is, tests generated from the pieces are valid in the originals. Also, one must be able to gauge how much of the original is covered by the tests generated, to judge whether more abstractions or different partitions are needed.

Second, limited nondeterminism must be allowed. In the simplest programs, each input produces exactly one output. Actually a range of responses may be acceptable, for instance, different orders of executing subtasks, small differences in numerical results, or arbitrary program-generated tags. The expected output produced in the test scenarios must cover a range of acceptable actual outputs, either explicitly or by reference to an abstract class.

Third, there must be a way to efficiently turn test suites into self-evaluating source code. Conceptually one specifies which calls correspond to each abstract test step, the test suite is macro-expanded into code, and dispatch and reporting code is added. In practice, this is far more complex. Innovative adaptations of existing test code generators is one possible approach.

Finally, tests must be traceable back to the original specification. The final executable test suite must report not only that a particular test failed, but also the part(s) of the specification that yielding that test. In other words, what lines, paragraphs, etc. of the specification the software does not satisfy.

As software becomes a bigger part of NIST standards, we want to spend our time developing standards, not generating acceptance tests. A highly automated, flexible, formally specified software test generation method allows us to put our time to best use and would be widely used in industry.

[1] “Model Checkers in Software Testing”, NIST-IR 6777

[2] “Abstracting Formal Specifications to Generate Software Tests via Model Checking”, NIST-IR 6405

9.06.06 Subtopic: Native Continuous Mesh Support in X3D for HANIM-2001 Utilizing the Cg Language

Extend an X3D [1] browser such that it's able to natively support the HANIM-2001 spec [2] via hardware rendering utilizing Cg. A key element is to be able to take a continuous mesh based avatar and display an animated avatar, for example using a motion capture file to animate the figure. The system must be able to animation a mesh of approximately 200,000 triangles at a rate not less then 20fps.

[1] http://ovrt.nist.gov/translators.html

[2] http://www.h-anim.org/

9.06.07 Subtopic: Secure Ad Hoc Wireless Networks

The ability to set up networks of sensors, workstations or other mobile or stationary units in an ad hoc manner using a hub-less architecture offers a number of advantages. These advantages include setup speed, robustness, minimal or no setup effort, and maximum range without the need to calculate positions for the Access Points. Ad hoc wireless networks are differentiated from infrastructure-based wireless networks by their routing protocols. A mobile ad hoc network, however, must be designed with appropriate security, otherwise an adversary may intercept, re-route or block information from reaching some or all the mobile nodes, or may mount attacks on otherwise “secure” higher-level protocols. Security measures for ad-hoc networks, therefore, need to be integrated into the routing protocols and can be troublesome and very costly to retrofit to existing systems that have not been designed with security from the onset. The focus of this research is to develop technologies that will enable efficient and secure ad hoc wireless networks to be deployed and commercialized with minimal or no changes to existing wireless link standards.

9.07 INTELLIGENT CONTROL

9.07.01 Subtopic: Applying AI Tools and Techniques to the Real-Time Control of Intelligent Systems

There is a clear gap between traditional Artificial Intelligence (AI) systems that typically work solely on symbolic representations, and real-time control systems that rely on processed sensor data, usually in the form of geometric knowledge or metrical maps. However, with constant advancements in object recognition technologies and the ever increasing computer processing speeds, these control systems seem primed to be able to leverage existing AI tools and techniques to allow for more suitable and robust control of intelligent systems.

This solicitation is seeking proposals for AI tools, representations and/or techniques that could enhance the ability of real-time control systems to understand the environment and propose suitable actions. Prime areas for applying AI techniques are in the areas of situation awareness and dynamic planning (also referred to in some domains as tactical behaviors); in particular, providing the ability for an intelligent system to be able to identify and understand a situation it encounters, be able to reason over the situation to deduce additional pertinent information, be able to understand the actions that are available to it when confronted with that situation, and be able to decide among those actions to determine which best accomplishes a given goal. The need for this type of deductive logic is ubiquitous, and can be applied to many manufacturing and non-manufacturing areas, ranging from manufacturing cell control to autonomous vehicle navigation.

The awardee(s) will work closely with NIST staff members who are developing control systems based upon the 4D/RCS reference model architecture. During Phase 1, the awardee(s) will be expected to provide a survey of AI techniques, representations, and tools that are best suited to enhance the 4D/RCS-based control system, and should demonstrate a proof-of-concept implementation of how these techniques would be applied to a sample scenario in the manufacturing or autonomous vehicle domain.

Collaboration will be limited only to NIST keeping awardee informed of any technical research at NIST that could impact the research and development.

References:

Albus J., and Meystel A., Engineering of Mind: An Introduction to the Science of Intelligent Systems, New York: John Wiley and Sons, 2001.

Evans, J., Messina, E., Albus, J., and Schlenoff, C., "Knowledge Engineering for Real Time Control," Proceedings of the International Workshop on Intelligent Knowledge Management Techniques (I-KOMAT 2002), Crema, Italy, 2002.

Uschold, M., Provine, R., Smith, S., Schlenoff, C., and Balakirsky, S., "Ontologies for World Modeling in Autonomous Systems," Submitted to the IJCAI'03 Conference: Workshop on Ontologies and Distributed Systems, 2003.

9.07.02 Subtopic: Next Generation LADAR for Industrial Autonomous Vehicles and Machine Automation

During the last few years, there has been a growing demand by industry for low cost, non-contact, high resolution and fast (real-time) scannerless 3D range imaging cameras. The needs expressed by industry, the military, and other government programs have been for robotics, autonomous vehicles, construction automation, automated manufacturing, topological mapping and automotive applications. The Industrial Autonomous Vehicles project, as part of the MEL Intelligent Control of Mobility Systems program, has identified uses of this technology in manufacturing. Some of the uses include: obstacle/object detection and identification, crash avoidance/path planning, indoor and outdoor autonomous navigation and map generation, safety management and control, and product integration and dimensional control and inspection. Improving the capabilities of automated material handling systems could significantly reduce manufacturing costs and improve productivity.

One promising, emerging active optical sensing technology to obtain range images quickly and precisely is laser radar (LADAR). However, present commercial LADAR sensor systems are relatively slow, bulky, and expensive. They typically use mechanical moving parts in order to generate a raster scan and provide a range image. Therefore, range measurements are made sequentially by steering the laser beam over the target area. These limitations limit the acceptance of LADAR in many industries.

Scannerless or Flash LADAR represents the next step in non-contact range imaging technology. These devices typically use pulsed or modulated lasers to floodlight illuminate the target scene. The Time-Of-Flight (TOF) of the laser illumination source to various surfaces in the scene is measured in parallel by each pixel of the detector to generate a range image. Because of the parallel measurements, the potential exists to achieve very fast frame rates and to produce small, lightweight, low voltage, power efficient sensors.

The US Department of Defense sees the benefits that can be gained from this emerging technology in military operations. DoD is currently providing most of the research and development support for Flash LADAR development. Their interest, however, is primarily for detection and identification of targets that are visually obscured by foliage or camouflage netting, and viewed mostly from airborne platforms. Although the technology development shows great promise for military use, the developers are not addressing the low cost needs of the industrial, transportation and commercial industries. For example: The AGV and servicing robot manufacturers are looking for sensor prices of $2000 or less per unit. Acceptable cost estimates for automotive applications are even less at a few hundred dollars per unit. Military sensors of this type, on the other hand, are expected to cost $10-30K.

We solicit proposals for the development of new Flash (Focal Plane Array) LADAR sensors to meet the performance and cost requirements for industrial and commercial applications. Our specific interest, at this time, is for Industrial Autonomous Vehicles. The ideal sensor for such applications would have the following characteristics:

- Range: Minimum < 1 m, Maximum > 20 m
- Range Accuracy: +/- 0.005 m
- Range Resolution: < 0.01 m - necessary to meet desired range accuracy at 10 Hz frame rate.
- Angular Resolution: ~0.0017 rad (~0.1 deg) or better
- FOV (field-of-view) per detector array: Azimuth ~ 0.5 rad (30 deg), Elevation ~0.5 rad (30 deg) or Azimuth ~3 rad (180 deg), Elevation ~0.5 rad (30 deg) per sensor assembly
- Frame Rate: > 10 Hz
- Wave Length: (800 nm to 1500nm)
- Power: sufficient to meet imaging requirements but must be eye safe
- Weight: < 1.4 kg (3 lb)
- Must operate in bright lights and sunlight
- Provide reflectance image and/or color image which is registered at pixel level
- Ability to handle multiple returns is desirable
- Little or no image blur from motion at vehicle speeds up to 2 m per second
- No moving parts
- Estimated large volume production cost of $1000 or less

Phase I: Develop new concepts in Flash (Focal Plane Array) LADAR technology for meeting the stated characteristics for IAV and machine automation. Collaboration or exchange of information between NIST and the company is highly encouraged during this phase.

Expected outputs include:

- Proposed concept design for high performance low cost imaging LADAR
- Optical power budget for various background light levels
- Algorithms for range and multi-range calculations
- A statement if desired characteristics can be met
- What would be necessary to meet listed characteristics

NIST has experience in testing and evaluating LADAR sensors for perception applications. NIST would collaborate with the awardee in data collection and experiments in NIST labs, in providing access to Robotic testbed platforms, and in conveying the desired characteristics of an active perception sensor for mobile platforms.

If a phase 2 award is made, an engineering sample LADAR development and demonstration will be expected. This phase could include collaborative/joint testing exercises at NIST to characterize sample sensor performance.

9.07.03 Subtopic: Laser Light Source for Illuminating Specularly Reflecting Droplets

Understanding of several high-speed industrial metals processing technologies such as atomization or spray deposition would be greatly improved by high-speed photography, which requires a visible light source to illuminate rapidly moving droplets. The particles and droplets generated by these processes are generally 5 to 100 μm in diameter and travel at velocities up to several hundred m/s. The specularly reflective surface of the metal droplets renders point source and collimated light unsuitable for the required reflected-light imaging of surface structure. A light source suitable for this purpose would need the capability to be synchronized with a high-speed movie or video camera (10,000 fps) where each frame could be exposed with one or more short duration (<100 ns) pulses, to create a flash illuminated image through telescopic/macro optics. An external sync oscillator connected to a copper vapor laser capable of 15 to 20 watts of light output with a fiber optic coupling to a beam expander and Lambertian scattering plate should provide sufficient brightness and dispersion for this application. Other laser or white light sources would be considered if the wavelength, pulse duration, power, and repetition rate were suitable for high-speed exposures. The awardee will deliver a prototype system to NIST for testing in a laboratory environment. NIST will collaborate with the awardee on the tests.

9.08 MANUFACTURING SYSTEM INTEGRATION

9.08.01 Subtopic: Computational Tools to Support Intelligent and Distributed CAD

Design of complex engineering systems is increasingly becoming a collaborative task among designers or design teams that are physically, geographically and temporally distributed. The complexity of modern products means that a single designer can no longer manage the complete effort. Designers are no longer merely exchanging geometric data, but more general knowledge about design and design process, including specifications, design rules, constraints, rationale, and more. As design becomes increasingly knowledge-intensive and collaborative, the need for intelligent CAD tools to support the representation and use of knowledge among distributed designers becomes more critical. The objective of this solicitation is a development of computational software tools to support intelligent and distributed CAD (IDCAD), or more specifically, frameworks for distributed design that will improve the ability to represent, capture and reuse design knowledge, and to enable design integration across time and space. Examples of challenges associated with IDCAD include but are not limited to knowledge-based CAD, knowledge capture and sharing, supply chain management, Internet-based communication, novel design agents, etc. An emphasis will be placed on software tools that are either compatible with hardware/ software platforms used by small to medium enterprises, or accessible from such platforms (e. g., via the Internet).   NIST will be willing to collaborate with the awardee and expects delivery of the Computational Software Tools developed.

9.08.02 Subtopic: Product Model-Based Simulation for Small and Medium-sized Enterprises (SMEs)

One key to enhance the competitiveness of U. S. small and medium-sized enterprises (SMEs) is their ability to simulate the physical behavior of products and manufacturing processes. Through techniques such as finite element analysis, SMEs can greatly impact products by optimizing their performance, judging design alternatives, and improving manufacturing yields. However, industry often does not benefit from such simulations due to the lack of easy-to-use product-specific capabilities. This situation is exacerbated in SMEs where limited resources typically preclude having in-house analysis tools and staff. Yet SMEs need analysis capabilities, as they are often the ones with the precise product and process knowledge required to realize improvements.

NIST is soliciting proposals for innovative software and technology infrastructure that will overcome these challenges. The following capabilities are required:

a) A methodology for creating highly automated analysis modules that can be deployed as self-serve Internet-based engineering web services.

b) A design-analysis interoperability architecture that enables such analysis modules. This architecture shall support a diversity of CAD tools, design domains, physical behaviors, solution methods, and CAE tools. It shall also capture idealization knowledge and support various levels of abstraction.

c) A standards-based approach for engineering frameworks that fills fundamental gaps including content coverage, content semantics, and fine-grained associatively.

This effort shall apply these general techniques to create capabilities that will aid printed circuit board (PCB) fabricators and designers in the electronics domain. Exemplar analysis modules shall be developed for behaviors that are not well supported today like PCB warpage. SMEs shall be able to feed these analysis modules with design information in the form of rich AP210 product models (the ISO 10303 standard for electronics).

The result of this effort will be methods, software tools, and web services with the above capabilities. Awardee(s) will provide prototype versions of these items in phase 1 and a working model in phase 2. It is expected that NIST will collaborate extensively with awardee(s).

References:

1. Systems Integration for Manufacturing Applications (SIMA) program. http://www.nist.gov/sima/

2. Infrastructure for Integrated Electronic Design & Manufacturing. http://www.eeel.nist.gov/811/manufacture.html

3. TIDE (Technology Insertion Demonstration Experiment) project. http://www.mel.nist.gov/msid/pe.htm

4. ISO 10303-210 standard for electronics. http://www.ap210.org/

5. Engineering Framework Interest Group (EFWIG). http://eislab.gatech.edu/efwig/

TIGER project. http://eislab.gatech.edu/tiger/

9.08.03 Subtopic: AP210-based PCB Stackup Design & Warpage Analysis

Printed circuit boards (PCBs) are multi-material structures that are one of the backbones of the electronics industry. As their performance requirements and complexities increase, the need also increases to better manage z-directional factors including warpage, impedance control, and plated through-hole reliability.

Reducing warpage in PCBs and other electronic packages is a particular challenge today for reasons including:

a) Warpage is a difficult phenomenon that depends on factors such as complex material behavior, fabrication processing, assembly manufacturing, and other environmental conditions (e.g., humidity).

b) The information needed to enable effective warpage simulation is not well defined and managed. The design and specification of PCB stackup (i.e., details about the z-direction PCB cross-section) is another key aspect that influences warpage. However, such design and fabrication knowledge is complicated, it often spans multiple organizations (e.g., the PCB design organization and the PCB fabricator organization), and it has no well-established exchange protocol.

c) The PCB design model has many circuit layout features that must be considered and yet idealized to create reasonable warpage analysis models. A rich design model is needed to feed this process, and a design-analysis interoperability architecture is needed to support various levels of abstraction and a diversity of CAD tools, material libraries, solution methods, and CAE tools.

Recent advances provide promising technologies and directions to help solve these problems. In particular the AP210 standard (ISO 10303-210) enables rich product models for electronics, while engineering framework concepts are emerging that help fill information gaps and enhance standards-based model interoperability.

NIST is soliciting proposals to provide innovative software tools that explore these technologies and their ability to solve the PCB warpage problem. This effort will focus on the highly automated analysis modules that guide PCB design and reduce warpage. Collaboration with other organizations is anticipated in the areas of fabricator needs and test usage, material characterization, and metrology (for results verification).

The result of this effort shall be software tools and techniques that embody the above capabilities. Awardee(s) will provide a software prototype and documentation in Phase 1 and a working model and software in Phase 2. It is expected that NIST will collaborate extensively with awardee(s).

References:

1. Papers about warpage issues and metrology. http://www.akrometrix.com/downloads.htm

2. Infrastructure for Integrated Electronic Design & Manufacturing. http://www.eeel.nist.gov/811/manufacture.html

3. Systems Integration for Manufacturing Applications (SIMA) program. http://www.nist.gov/sima/

4. ISO 10303-210 standard for electronics. http://www.ap210.org/

5. TIGER project. http://eislab.gatech.edu/tiger/

6. Engineering Framework Interest Group (EFWIG). http://eislab.gatech.edu/efwig/

9.08.04 Subtopic: Integrated Process Modeling

The vision of "first part correct" demands a different approach in many areas of manufacturing engineering. New concepts such as predictive process engineering and science-based manufacturing will require a physics-based understanding of material removal manufacturing processes, advanced process metrology methods, valid analytical models to predict process performance and optimize manufacturing decisions, and rigorously-defined representations for manufacturing process information. There will be a shift from classical feedback quality assurance and optimization to model-based feed-forward process design and quality control. Product and process designers will have knowledge of and access to process specifications, manufacturing knowledge, and predictive process models to generate product and process designs seamlessly to produce the correct part the first and every time. To meet these needs, a number of areas are being addressed in parallel.

The existence and usability of process characterization models represent a central component of the first part correct vision. The process models describe the manufacturing process capabilities based upon proven theories and techniques, including analytically derived relationships, dynamic equations, empirical correlations, and statistical inferencing. Key issues include (1) validation of the process models to ensure accurate results and to instill confidence to potential users and (2) usability of the process models to integrate and incorporate these models into engineering applications throughout the product lifecycle where decisions are made. To improve manufacturing productivity and reduce lifecycle costs, appropriate mechanisms must be developed to enable use of manufacturing knowledge throughout the entire product lifecycle.

NIST is requesting proposals to address tools, methods, data representations, and/or prototype implementations for validation of physics-based process models for milling and turning operations and integration of these models to improve engineering applications. The focus of this effort will be on use of the process model as a tool, rather than viewing the model as an end-goal in itself. As part of this work, software modules will be created and supplied to NIST that will integrate with and extend the capability of the existing Process Integration Framework effort. This NIST activity is developing an integration framework and prototype agent-based software system to improve product design, manufacturing process planning, and machining execution through use of process knowledge from predictive models. Further, use of the current draft standard Process Specification Language (PSL) is strongly recommended. The awardee will work closely with NIST staff who are developing relevant process models, PSL, and prototype implementations of the Process Integration Framework. During Phase I the awardee will be expected to deliver software source code and initial demonstration capability in one or more of the areas indicated for proposal topics. During Phase 2, if awarded, an extended implementation will be expected along with delivery of the software source code.

The company would be given detailed information about, and possibly access to, if needed, a prototype software system developed at NIST for the Process Integration Framework.

9.08.05 Subtopic: Next Generation Process Exchange Tools and Applications

As manufacturing companies move toward increased integration, there is a growing need to share process information in addition to product data. Software applications range from those that simply portray processes graphically to tools that enable simulation, planning, analysis, scheduling, and/or control of processes. In collaboration with industry and academia, NIST is developing a Process Specification Language (PSL) that will be common to all manufacturing applications, generic enough to be decoupled from any given application, and robust enough to be able to represent the necessary process information for any given application. Additionally, the PSL will be sufficiently well defined to enable exchange of process information among established applications.

NIST is requesting proposals for computer-based software tools to facilitate the use of the PSL for process modeling and process information exchange. Proposals should target the specification and design of generic PSL-based development and integration of software tools or software application extensions to existing manufacturing application software. Solutions could involve the development of translators or wrappers for exchange, or tools for creating and editing PSL presentations. NIST will be willing to collaborate with the awardee and expects delivery of the Computational Software Tools developed.

References:

1. Internet site: http://www.nist.gov/psl/

2. Schlenoff, C., Knutilla, A., Ray S., "Unified Process Specification Language: Requirements for Modeling Process." NISTIR 5910, National Institute of Standards and Technology, Gaithersburg, MD, 1996.

3. Knutilla, A., Schlenoff, C., Ray, S., "Process Specification Language: Analysis of Process Representations." NISTIR 6160, National Institute of Standards and Technology, Gaithersburg, MD, 1998.

4. Gruninger, M. and Menzel, C. Process Specification Language: Principles and Applications, to appear in AI Magazine (may also be found at http://www.mel.nist.gov/psl/pubs.html).

5. Ciocoiu, M., Gruninger M., and Nau, D. (2001) Ontologies for integrating engineering applications, Journal of Computing and Information Science in Engineering 1:45-60. Schlenoff, C., Gruninger, M., Ciocoiu, M., (1999).

6. The Essence of the Process Specification Language, Transactions of the Society for Computer Simulation vol.16 no.4 (December 1999) pages 204-216.

9.08.06 Subtopic: Ontological Engineering Applied to Manufacturing System Integration Research

Proposals are solicited for the application of the principles behind ontological engineering towards the area of manufacturing systems integration and/or research. The result of this effort will be mechanisms, infrastructures, and/or methodology tools with an ontological underpinning that will facilitate the interoperability of manufacturing systems. Within the former area, these principles may be applied to information that is to be shared among manufacturing applications, including, but not limited to, process, resource, product, and design information. Special emphasis will be given to proposals that are applicable to multiple types of information.

In the context of this proposal, an ontology is an explicit treatment of some topic as a written report. Included in this report would be the ontological formal and declarative representation, which includes the vocabulary (or names) for the terms in that subject area and the logical statements that describe what the terms mean and how they can or cannot be related to each other. The report should reflect that ontologies provide a formal means for representing and communicating knowledge about some topic and a set of relationships that hold among the terms. Without these formal and concise definitions of attributes, relations, and concepts, usually built upon some type of foundational theory, integration of manufacturing applications runs the risk of misinterpretation of those concepts, leading to problems with interoperability and exchange.

NIST will be willing to collaborate with the awardee.

References:

1. Knowledge Sharing Effort, Internet site: http://www.cs.umbc.edu/kse/.

·2. Ontolingua Server Project, The, Internet site: http://ksi.cpsc.ucalgary.ca/KAW/KAW96/farquhar/farquhar.html.

3. Plan Ontology Project, Internet site: http://www.aiai.ed.ac.uk/~bat/ontology.html.

4. Process Interchange Format, Internet site: http://ccs.mit.edu/pif/.

9.08.07 Subtopic: Manufacturing Data Exchange Standards Interoperability Testing Tools

Manufacturers attempting to solve Computer Aided Design (CAD) and Computer Aided Engineering (CAE) interoperability problems through use of the international Standard for the Exchange of Product model data standards (STEP) require objective technical means to assure the compatibility of commercial software applications. Similarly, commercial software vendors, seeking to satisfy their customers, seek the capability to test their STEP implementations during the development cycle. Software deployment pilot programs are an effective means to test implementations to information exchange standards. However, test pilots can not be effective unless tools are available to isolate sources of exchange errors. Once isolated, translator errors and incompatible interpretations of a specification may be rectified in order to improve the capability of the participating implementations.

NIST is soliciting proposals to provide the technical infrastructure software tools necessary to support STEP implementation interoperability testing trials and to realize STEP conformance testing services. The focus of this effort is in the following areas:

Computer Aided Design to Computer Aided Manufacturing – Numerical Control (NC) for Machine Tools.

Computer Aided Design to Computer Aided Engineering – Finite Element Analysis (FEA)

The result of this effort shall be written reference test case data and test metrics for exchange testing as well as software tools capable of validating that neutral exchange data meets the requirements of the specified standard.

NIST will be willing to collaborate with the awardee.

9.08.08 Subtopic: Testability of Complex Manufacturing Software Systems

Software systems used in manufacturing enterprises are large and highly complex. Manufacturers must integrate these software systems such that they dynamically interact with one another using standards interfaces. Those involved in these integration efforts are frustrated by the lack of practical testing methods for these interacting software systems, by the ineffectiveness of existing testing tools, and by the lack of consideration for testing that standards-developers employ when developing standards in this domain.

NIST is soliciting proposals to identify and develop software tools and written techniques for specifying, locating faults in, and testing conformance of interaction-driven manufacturing systems as well as developing and documenting methods for designing integration specifications with improved testability. The results of this effort shall be the development and documentation of prototype testing methods, leveraging existing ITL methods where appropriate, and the development of corresponding software tools. Offerors should identify in their documentation the characteristics of “testable” implementations and devise specification methods applicable to integration specification developers.

NIST will be willing to collaborate with the awardee.

9.08.09 Subtopic: Adapting the High Level Architecture’s Run-Time Infrastructure for Manufacturing

Today, as manufacturing companies are creating larger and more complex simulation models for analyzing their operations, the need for accessible distributed simulation technologies is increasing. The Defense Modeling and Simulation Office (DMSO) of the Department Of Defense (DOD) created an architecture for distributed simulation called the High Level Architecture (HLA) for use defense simulations. The HLA Run Time Infrastructure (RTI) defines interfaces and protocols through which simulations (referred to as federates) can be integrated into distributed simulations (referred to as federations). The HLA defines methods for the creation of objects (data entities whose lifetime and value is controlled by federates) and interactions (instantaneous messages exchanged between federates in the federation). The semantics information about objects and interactions is defined using an HLA technology called the Object Model Template (OMT).

While the HLA and the RTI are in wide use in the DOD simulation community, there are several usability issues that have limited their widespread adoption in the manufacturing community. Some of these issues are that the RTI is very complex, requires specialized training to proper use, requires a significant amount of coding to create a simulation, and it does not integrate easily with the commercial discrete event simulations used in the manufacturing domain.

To address some of the issues hindering the use of HLA technology by manufacturers, NIST developed a prototype implementation of a software component called the Distributed Manufacturing Simulation Adapter (DMS Adapter). The DMS Adapter connects to an RTI implementation and provides a simplified interface and protocol that facilitates the integration of commercial of the shelf (COTS) simulations into distributed simulations. It provides the capability to: define objects and interactions using the eXtensible Markup Language; create new or change existing definitions of objects and interactions without the need to recode the simulations; store, update, and exchange ownership of object instances; and to integrate COTS simulations without requiring vendor changes to their baseline products. Information about the current implementation of the DMS Adapter can be found in the references or can be acquired from the Technical Representative.

NIST is requesting proposals for computer-based software applications that either:

1) Integrate the capabilities of the DMS Adapter into existing COTS simulation products or,

2) Extend an RTI implementation with the capabilities of the DMS Adapter

Proposals should expect to provide an evaluation of the current DMS Adapter specification and prototype implementation, to propose changes or extensions to the interface, to provide development plans for implementation of the improved interface, and to identify issues and propose solutions to issues associated with implementing the interface.

NIST will be willing to collaborate with the awardee.

References:

1. Riddick, Frank , McLean, Charles , The IMS Mission Architecture for Distributed Manufacturing Simulation, NISTIR 6559, (2000).

2. McLean, Charles , Leong, Swee , Riddick, Frank, Integration of Manufacturing Simulations Using High Level Architecture (HLA), Proceedings of the 2000 Advanced Simulation Technologies Conference (ASTC 2000), (2000).

3. McLean, Charles , Leong, Swee , Riddick, Frank , Architecture for Modeling and Simulation of Global Distributed Enterprises, Proceedings of the ASIM 2000 Conference, (2000).

4. Riddick, Frank, The Distributed Manufacturing Simulation Adapter Reference Guide, to be published as a NISTIR, (2003) and available upon request.

9.09 MICROELECTRONICS MANUFACTURING

9.09.01 Subtopic: Superconducting Phase Reference Device for Nonlinear Measurement Systems

There has been increasing interest over the past several years in accurately characterizing the nonlinear response of electronic components, particularly at microwave frequencies. For example, the nonlinear response of microwave components in wireless communications systems can create detrimental interference signals that are difficult to predict or model. These problems will only worsen over time as communications bands become more crowded. To address the growing problem of nonlinear device behavior, there has been a sharp increase in recent years in the development and use of microwave frequency nonlinear measurement systems, in order to more accurately characterize the nonlinear response of electronic components. However, difficulties in calibrating and comparing different nonlinear measurement systems have slowed progress in the development of these measurement techniques and instruments, which are vital for understanding nonlinear response at the system and component level. There is currently an urgent need for nonlinear reference devices, which possess known nonlinear response in both magnitude and phase, in order to advance the growing field of nonlinear device characterization.

High-temperature superconductors have been shown to possess a nonlinear response at microwave frequencies. Based on the current understanding of the origin of such nonlinear response, a delay line fabricated from a YBCO film operated at around 76 K could be used to generate nonlinear harmonic signals with a known magnitude and phase relationship to the fundamental signal. Such a device would be useful as a reference device for comparing and/or calibrating a variety of different nonlinear measurement systems.

We seek a prototype stand-alone harmonic reference device as a deliverable in Phase I. This device will consist of a 50Ω transmission (delay) line fabricated from a thin film of the high temperature superconductor YBCO integrated in a controllable cryocooler. This device will be evaluated primarily as a phase reference device. Such a delay line needs to demonstrate stable operation in the temperature range 60 K – 76 K, and needs to be integrated with a controllable cryocooler for portability and ease of use. Such a delay line should exceed 0.2m in total length, and needs to have interconnects to room temperature that have a stable phase response on thermal cycling. If successfully implemented, such a device could find application in the growing field of nonlinear measurement systems for evaluation of electronic components.

The goal of Phase 1 is to demonstrate that this technology can deliver a reference device with the desired properties in a portable cryopackage that is stable during a single measurement cycle and when cycled over time. Phase 2 effort would involve further development of the harmonic reference device based on detailed evaluation of the prototype delivered in Phase 1.

9.09.02 Subtopic: Rapid Thermal Annealing System with Temperature-Time Gradient

Short-time annealing or rapid thermal annealing (RTA) is a common and important step in processing electronic materials into device structures. RTA is employed to improve crystallinity and to modify electronic properties of thin film and bulk crystals, to bond layers of different materials (metal to metal, metal to ceramic), and to clean or modify film surfaces by thermal evaporation, oxidation, and nitridation.

NIST is developing a combinatorial methodology for processing and characterization of thin film electronic materials. It involves RTA process optimization for specific experimental setups with a variable space that includes annealing temperature, time and ambient gas. The limitation of present industrial and laboratory RTA systems is that they only provide uniform temperature distribution across the whole annealing chamber at any given time, and do not allow variation of either temperature or time of annealing as a function of specific position in the chamber. This limits throughput of experimentation and testing ability to study effect of temperature-time gradient across the combinatorial array of samples.

We are requesting proposals to develop and to deliver an RTA system with temperature-time gradient capability. The system should provide independent control of both annealing temperature and annealing time across the chamber. The RTA system with integrated PC controller is required to meet the following specifications: 1) controlled (programmable) temperature gradient in the test samples up to 10 degrees/mm in at least one direction on a length scale of up to 150 mm, 2) controlled time of annealing in the range from several seconds to several minutes along the same direction(s) in the chamber, 3) multiple points accurate temperature monitoring across the sample with the ±3 oC accuracy and ±1 oC precision; 4) multi-gas capability allowing heat treatment of the samples in various gas mixtures, 5) accommodating large size samples (up to 150x150 mm square samples or 15 cm (6”) wafers for combinatorial studies.

Phase 1 results are expected to demonstrate the feasibility of the newly developed prototype RTA system to produce and to monitor the temperature-time gradient on 2” metal coated ceramic test wafers supplied by NIST. It is expected that at the end of Phase 2 the awardee will manufacture and deliver the prototype RTA system to NIST facilities.

NIST will be willing to communicate with the awardee throughout the research, provide test samples, do the test annealing runs, and ensure the specifications are met.

9.09.03 Subtopic: High Throughput Modification of Wide Bandgap Semiconductors for Device Performance Optimization

Wide bandgap compound semiconductors and their alloys find increasing application in optoelectronic (LEDs, lasers, detectors) and microelectronic (high-temperature, high-power, and high-frequency transistors) devices. However, the performance of such devices is limited by several materials and engineering problems, including a difficulty in making thermally stable low-resistance electrical contacts to wide bandgap semiconductors. Achieving low contact resistivity is hindered by the energy barrier formed at the metal/semiconductor interface, and depends on several factors including the sheet resistivity of the semiconductor wafer and metallization composition. Reduction of sheet resistance and the optimization of the heat treatment schedule as well as the best metallization composition requires extensive experimentation in a multi-parameter space as well a method to organize this information for future reference. Thus, the methods of high throughput research (combinatorial materials science) are ideal for this problem.

The awardee is expected to develop a system to produce libraries of materials for optimizing wafer sheet resistivity, based on the current state-of-the-art. Phase 1 results are expected to demonstrate the feasibility of the newly developed technique to produce sample libraries with continuous or discrete variation in sheet resistivity as applied to wide bandgap semiconducting materials of various types, as well as delivery of prototype wafers to NIST for testing and evaluation. Inclusion of a system for automated sample preparation, to facilitate subsequent measurement of electrical and electronic characteristics as well as composition in each element of the array, is desirable. The ability to modify semiconductor wafer properties at elevated temperatures, thus avoiding post-processing heat treatment step, is also an important issue.

9.09.04 Subtopic: Development of a Laboratory Scale CD-SAXS Device

The production of semiconductor circuits and nanofabricated devices requires measurement devices capable of monitoring pattern dimensions and pattern quality in a variety of materials ranging from polymer-based photoresists to silicon oxide and finally metal interconnects. Current devices used for process optimization and control are based on scanning electron microscopy and visible light ellipsometry. The drive to produce circuits with a minimal dimension, termed a critical dimension, approaching 30 nm in line width within the next five years will challenge both techniques in the characterization of dense patterns with aspect ratios of > 6 in a rapid, non-destructive manner. In particular, the capabilities of visible light based techniques are expected to decrease dramatically.

NIST has developed a metrology technique based on transmission small angle x-ray scattering for the measurement of critical dimension and pattern shape (CD-SAXS). The technique has been developed using synchrotron radiation, however experiments indicate the feasibility of a laboratory scale device. The technique offers the possibility of rapid, non-destructive characterization with sub-nanometer precision on dense patterns approaching 10 nm in width. The technique has already been successfully demonstrated on the full range of materials currently used in microelectronic fabrication including photoresists and copper interconnects.

We are requesting proposals to develop and deliver a laboratory scale device capable of performing CD-SAXS measurements. Required capabilities of the technology are 1) a transmission geometry capable of measurements on actual industrial test samples without modification, 2) an optical configuration to allow measurement of standard industrial test samples with patterned area of 50 x 50 microns or less, and 3) a detection system capable of precisely locating the position and measuring the shape of the resulting diffraction peaks, including an angular range of measurement capable of measuring more than 10 orders of diffraction from samples with periodicities varying from 10 to 150 nm. Specific system requirements are given below:

1. X-ray source:

   a. Mo tube, 0.5 mm x 0.5 mm beam size at sample position
   b. Flux not less than 106 cps,
   c. Beam divergence (FWHM) < 0.005°
   d. Wavelength dispersion, Δλ/λ, less than 10-4 .

2. Detector system(single channel for Mo radiation):

   a. Dark current less than 0.1 cps
   b. Acceptance beam divergence (FWHM) < 0.005°

3. Two-circle goniometer:

   a. Horizontal θ-2θ
   b. Reproducibility ±0.0001°
   c. Smallest step 0.0001°

4. Centric sample cradle:

   a. Motorized Chi and Phi rotations and X-Y-Z translations
   b. Reproducibility for both Chi and Phi close to ±0.0001°
   c. Reproducibility for X-Y-Z less than 2.0 μm

5. Measurement of the scattering peak profile along the azimuthal direction orthogonal to the θ-2θ scan with a precision close to ±0.0001°. Two possibilities; a linear position sensitive detector mounted vertically on the detector arm or a high precision Chi & phi circle on the sample cradle.

6. 2-D detector for Mo radiation:

a. 10 cm x 10 cm active detection area
b. 50 μm spatial resolution

A configuration composed of items 1 – 4 will be the normal set-up for high resolution CD measurements. Item #5 shall be placed after item #2 for a quick glimpse of the diffraction patterns and for sample alignments. Item # 5 needs to be housed inside a vacuum tube with a beam path expandable to 4 meters.

Phase 1 results are expected to demonstrate the feasibility of the instrumental design, while the delivery of a functioning device is expected at the end of Phase 2. NIST intends to communicate with the awardee(s) during the project, providing technical advice and test samples.

9.10 MICROFABRICATION AND MICROMACHINING

9.10.01 Development of Bi-directional Quantitative Dynamic Probe Capable of Measuring Poisson Ratio for Time Dependent Materials at Nanoscale

Progress in polymer durability, adhesion, yield and fracture have led to good understanding of the effect of primary uniaxial properties on performance of polymeric surfaces. Though, nanoscale, multidirectional measurements of the dynamic behavior of polymer surfaces is now needed to further understand structure/property relationship for surface durability and adhesion. This proposal solicits the development of a bi-directional sensing probe for dynamic quantitative measurements of load, displacement, and stiffness at nanoscale in the normal and lateral directions. Resolution and noise level should allow for sub-nanometer measurements. Loads and displacements should be controlled and synchronized in order to reduce or eliminate crosstalk between the two axes and other artifacts on the dynamic measurements. Phase 1 should demonstrate feasibility of sensing device and ability of algorithms to measure dynamic response of the contact without any influence of the control process. Development of a prototype and delivery of feasibility results are required in Phase 1 for evaluation by NIST Staff.

The objective of the Phase 2 is the delivery of a fully functional device with calibrated performance and accuracy. This system should be compact and robust as well as easy to use. Collaborative work between NIST and the company is anticipated for evaluation of feasibility results in Phase 1, as well as for testing reference materials provided by NIST for verification in Phase 2.

9.10.02 Subtopic: Development of Meso Scale Machine Tools

The micro-meso fabrication market is expanding to meet the demand for increased functionality, reliability and performance for smaller components that are frequently used in optoelectronics, medical equipment, sensors, communications, aerospace and automotive industries. In manufacturing of micro-meso products, machining has significant advantage in being able to generate three-dimensional complex shapes out of wide range of materials. In addition to being very agile, machining is also able to produce high accuracy and surface finish compared to other manufacturing methods. Therefore, meso machine tools are clearly one of the most important enablers in micro-meso manufacturing. Improvements in machine tool technologies are tightly coupled with the development of proper metrology tools and methods as evidenced by the improvements in CMMs and conventional machine tools.

NIST is currently exploring the metrology challenges and opportunities for such machines. The metrology challenges include 1) the required dramatic improvements in machining accuracy, 2) the lack of space for metrology components, 3) the difficult application of process-intermittent inspection due to the small feature sizes, and 4) the difficulties in achieving repeatable part fixturing, requiring multiple operations in one setup. The small work volume required by the machining applications, however, also presents unique opportunities for the application of superior metrology concepts that radically depart from classical machine tool metrology.

In order to facilitate these efforts, NIST is seeking proposals to design and develop innovative multi- axis meso-scale machine tools that would serve as test platforms for developing and evaluating new metrology tools and concepts as well as research in micro-meso scale machining. The machine that is of interest would have a work volume of 50 mm cubed or less. The proposed work should involve prototype development. At the end of Phase 1, delivery of the prototype system to NIST for further metrology research is expected. During Phase 2, if awarded, the company may have access to NIST testing and characterization capabilities.

Proposals that emphasize low cost and innovative structures, drive/actuator, metrology and sensing technologies while addressing the challenges mentioned above are strongly encouraged.

NIST will be willing to collaborate with the awardee.

9.11 MICROWAVE TECHNOLOGY

9.11.01 Subtopic: Calorimeter Compatible Microwave Power Sensors

NIST's present microwave power standards consist of a set of calorimeters and bolometric detectors. The bolometric detectors are generally modified versions of commercial bolometric detectors. [1] The bolometer is a temperature sensitive resistor that is maintained at a fixed resistance using a NIST Type IV power meter which is a DC quasi-bridge circuit. [2] The bolometric elements in NIST's standards are thermistors and thin film resistors. The power measurement is based on the principle of DC substitution. The RF power dissipated in the sensor is determined from the change in DC power as measured by the Type IV meter. The RF/DC substitution is not exact because RF power is dissipated in the input section of the sensor. Thus these devices are calibrated in a NIST calorimeter [3,4] to determine their effective efficiency. Because these devices are directly tied to a primary standard, they have the lowest uncertainties available.

We are no longer able to obtain commercial bolometric sensors for the WR-15 (50-75 GHz) and WR-10 (75-110 GHz) waveguide bands or with a 2.4 mm coaxial connector (0-50 GHz). The reasons for this include difficulty in obtaining good thermistors, and the limited dynamic range and speed of these sensors. For most commercial users, they have been supplanted by thermoelectric and diode sensors. Nevertheless, there is still a significant market for this type of sensor in standards labs due to their low uncertainties. An innovative product by a small company could fill this niche or expand it by improving on the capabilities of bolometers.

We are looking for a small company that is willing to design and build sensors that can be calibrated in our calorimeters. Phase 1 will consist of the preliminary design of the sensor. In Phase 2, prototype sensors will be made and tested in the NIST calorimeter. By the end of Phase 2, a final design and sensor should be produced and delivered to NIST. The solicitation is open to any calorimeter-compatible sensor, including non-bolometric sensors as well as thin film and thermistor units.

NIST will work with the company to ensure that the sensor designed will be compatible with our needs.

References:

[1] Fred R. Clague and Paul G. Voris, "Coaxial Reference Standard for Microwave Power", NIST Tech. Note 1357 (April 1993) describes one of these sensors.

[2] Neil T. Larsen, "A New Self-Balancing DC-Substitution RF Power Meter", IEEE Trans. Instrum. and Meas., IM-25 (4), pp. 343-347 (1976).

[3] Fred R. Clague, "Microcalorimeter for 7 mm Coaxial Transmission Line", NIST Tech. Note 1358 (Aug. 1993).

[4] J. Wayde Allen, Fred R. Clague, Neil T. Larsen, Manly P. Weidman, "NIST Microwave Power Standards in Waveguide", NIST Tech. Note 1511 (Feb. 1999).

9.11.02 Subtopic: Traceable Transfer Standards for Electrical Waveform and Phase Measurement

Objective: Develop an electrical pulse and phase standard traceable to NIST's Electrooptic Sampling System for use in microwave and millimeter-wave measurement systems. The standard will be used for time domain pulse and frequency-domain phase calibrations of instruments such as high-speed oscilloscopes, vector signal analyzer, IF down converters and communication system receivers.

Description: A need exists for traceable standards for calibration of high speed pulse and microwave measurement systems with bandwidths in the range of 20-110 GHz. Current calibration methods result in unacceptable waveform and electrical phase uncertainty at microwave and millimeter-wave frequencies. The proposed system will consist of a modulated signal source traceable to NIST's Electooptic Sampling System. The calibrated source will be used as a standard to calibrate other instruments such as high-speed oscilloscopes, microwave vector signal analyzers, large-signal vector network analyzers, IF down converters, and communication system receivers.

Phase 1: Demonstrate the feasibility of the development of a calibrated high speed pulse and electrical phase measurement standard. Conduct an analysis of its expected performance, accuracy, repeatability, and bandwidth when used to calibrate a system such an oscilloscope, microwave vector signal analyzer, or large-signal vector network analyzer. Conduct any critical bench-scale hardware tests needed to assess the uncertainties, risks and payoffs of the proposed calibration system, and assess potential bandwidth limitations.

Phase 2: Fabricate a 50 GHz or 110 GHz prototype of the calibration standard, based on results of Phase 1 feasibility study. Work with NIST to perform traceable calibration and characterization of the standard. Demonstrate its performance through calibration of a system such as an oscilloscope, vector signal analyzer, or large-signal vector network analyzer. Perform detailed measurements and analysis to determine the achieved calibration accuracy and repeatability, and deliver prototype system to NIST. The calibration standard or standards will be integrated into a calibration system. It will have a configuration which allows for application to a variety of pulse and microwave measurement systems.

Private Sector Commercial Potential: A traceable calibration standard has commercial potential for accurate calibration of high-speed oscilloscopes, large-signal vector network analyzers, and modulation circuits and sources used in communication systems and military pulse systems such as radar.

References:

[1] T.S. Clement, P.D. Hale, D.F. Williams, and J.M. Morgan, "Calibrating photoreciever response to 110 GHz," 15th Annual Meeting of the IEEE Lasers and Electro-Optics Society Confrence Digest, Nov. 10-14, 2002, Glasglow, Scotland.

[2] D.F. Williams, P.D. Hale, T.S. Clement, and J.M. Morgan, "Calibrating electro-optic sampling systems," Int. Microwave Symposium Digest, Phoenix, AZ, pp. 1527-1530, May 20-25, 2001.

[3] D.F. Williams, P.D. Hale, T.S. Clement, and J.M. Morgan, "Mismatch corrections for electro-optic sampling systems," 56th ARFTG Conference Digest, pp. 141-145, Nov. 30-Dec. 1, 2000.

9.11.03 Subtopic: Sampling Broadband RF Signals for Mixer Circuit Measurements

Summary Statement

In order to fully characterize the response of RF and microwave mixer circuits, the microwave community requires a new sampling technology. This new technology must be capable of sampling periodic broadband RF signals that contain numerous frequency components that are not harmonically related. It must also provide a method of correcting the sampled signal for the imperfections of the sampler itself, as it is often hard to identify the response of an RF device under test from that of the sampler response when operated at microwave frequencies. The development of the sampling technology and calibration methods will provide new capabilities beyond what is now available, or known to be available. It will enable nonlinear circuit characterization and the exploration of microelectronic device behavior that is not possible at this time, and will provide significant technological advantages to the nonlinear RF circuit measurement work NIST and to the radio-frequency technology community at large.

Sampler Goals

We envision an instrument or instrument subsection with 4 to 6 inputs. Each input will be sampled in order to recover all the significant spectral components of each broadband input. The output of the instrument block will either be calibrated, time-sampled data, or a down-converted representation of the input. If the later, we require a calibration procedure to remove the complex transfer function of each sampler from each of the 4-6 signals. The calibration procedure should be provided in software. All solutions should provide ready access to the most basic signal or data for NIST calibrations and statistical evaluations.

The input bandwidths would ideally cover a span from dc to 50 GHz. As this is known to be quite difficult, research in a sub-range would provide valuable information. If a down-converter is developed, it’s output

(IF) bandwidth should be in the range of 4-40 MHz. The sampler should also be sensitive to components at small signal amplitudes (-60 dBm, or less, for example) with as broad a dynamic range as possible.

While electrical sampling is a likely technology to pursue, optoelectronic sampling is a possible option. However, the inputs will always be electrical, delivered on coaxial cable using 2.4 mm connectors. The output can be either data or electrical signals for subsequent time-sample digitization.

9.11.04 Subtopic: Miniature Standard Microwave Radiation Source

The compatibility, operability, and safety of electronic systems in the presence of microwave radiation are critical to our high-technology society. Microwave sources are everywhere; cell phones and wireless communications systems, police and airport radars, commercial communications links, and computer systems with clock speeds up to several Gigahertz. The deployment of hostile microwave sources capable of disrupting critical electronic systems presents a real threat to homeland security as the list of products which may be sensitive to microwaves is almost endless.

The Radio-Frequency Technology Division of NIST, along with leading electronics companies, standards organizations concerned with electromagnetic compatibility (EMC), and various agencies around the world have programs to develop and improve testing methods and mitigation techniques (shielding, filtering, etc.) which will lead to more immune products and systems. As part of the NIST program to provide standards and reference measurements for these testing methods, we developed an optically coupled, remotely controlled low power radiating sphere [1]. This device could be well characterized both analytically and through measurement, providing an ideal standard source. The device has been an important tool for comparing and evaluating measurement facilities, determining shielding performance of equipment cabinets and cases, and serving as a check standard for uncertainty evaluations. Unfortunately, the NIST design is limited to 1.5 GHz while current needs extend to 10 GHz and higher. The first device had some commercial success but the cost limited customers to larger companies and government test laboratories. Potential customers for a new less costly device would include independent and in-house EMC test lboratories, manufacturers and users of shielded cabinets (i.e. computers, industrial controls, etc.), and commercial, university, and government research laboratories.

The new device should have the following characteristics at final delivery to NIST:

· Geometry (e.g., sphere) should lend itself to analytic or numerical modeling.

· Use the latest circuit components and technology to maximize the output signal and minimize battery drain (it may be possible to supply dc power using optical techniques but previous attempts have been expensive).

· Usable to 10 GHz or higher with radiated output well above all EMC emissions limits. Output should be extremely stable and repeatable.

· Small size (10cm diameter or less) and electrically isolated from the control unit (previous device used optical fiber and lasers).

· Able to be controlled by automatic test systems found in typical microwave laboratories.

NIST will consider requests for limited consultation and guidance as well as access to NIST testing and characterization.

Reference:

[1] G. Koepke, L.D. Driver, K. Cavcey, K. Masterson, R. Johnk, M. Kanda, "Standard Spherical Dipole Source," Natl. Inst. Stand. Technol. Tech Note 1351, 1991.

9.12 OPTICS AND OPTICAL TECHNOLOGY

9.12.01 Subtopic: High Efficiency High Speed Optical Switch

With the advent of quantum communication/cryptography and quantum computation there is a critical need for efficient optical processing of individual photons. In particular, there is a need to develop sources of single photons on demand. At least one of the many schemes proposed to create such a source requires an optical switch that can take number of incoming optical fibers lines, one of which may be known to contain a single photon, and direct that line to a single output fiber. Thus what is needed is a nx1 switch with the following characteristics. The overall optical loss should be as low as possible with 2 db or less as a good target goal. A good portion of this effort is likely to be in the area of better mode coupling between waveguide switches and optical fibers (which are currently mismatching in size). The switching time (including the transition time and propagation time of the control circuitry) should be fast to minimize the need for excessively long delay lines with goals of 10 ns and 1 ns for the propagation and transition times respectively. Because the polarization of the light is critical, polarization-maintaining optics must be used. Some applications require switching for a specific polarization only, while others may require the switch to operate for an unknown polarization. A switch meeting the former is acceptable, but a polarization independent switch would be preferable. In phase 1, the company would be expected to deliver to NIST a prototype switch or component of a switch demonstrating at least one of the above characteristic that is a significant improvement over what is available today. (The above described switch also has implications for the conventional communication industry, but that is not the basis for this solicitation.)

NIST will be involved in verifying the operation of the prototype. Though not required, to facilitate progress, NIST may be willing to consider providing access to its capabilities, as appropriate.

9.12.02 Subtopic: Manufacture of Thin Superconducting Films with Reproducible Transition Temperature

Superconducting transition edge sensors (TES) are incorporated at NIST and elsewhere into a variety of applications including single photon detection for quantum communication, and photon detection for astronomical applications. A critical component in the TES is a superconducting thin film with precisely controlled transition temperature (Tc). While TES have been fabricated by making a large number of films and sorting those with acceptable Tc, the fabrication process is neither well-understood nor well-controlled. Widespread adoption of these TES devices is dependent on a reliable commercial source of suitable superconducting films.

Critical film specifications are:

Superconducting transition temperature (Tc)—150 mK ±20 mK (3s)

Thickness—20 to 40 nm

Substrates—Si, SiN and SiO_2

Composition—W or Hf

Proposals are requested for innovative approaches to the synthesis of these thin films. The Phase 2 deliverable would be documentation and demonstration of a process operating under statistical control which meets the critical specifications. Proposals incorporating the use of 6 sigma or similar process development methodologies are encouraged. NIST would make facilities available for electrical testing at temperatures down to 60 mK should this be required.

References:

Aaron J. Miller, Sae Woo Nam, John M. Martinis, and Alexander V. Sergienko, "Demonstration of Low-Noise Near-Infrared Photon Counter With Multiphoton Discrimination", Applied Physics Letters, v. 83, 791-793 (2003).

R. W. Romani, A. J. Miller, B. Cabrera, and E. Figueroa-Feliciano, "First Astronomical Application Of A Cryogenic Transition Edge Sensor Spectrophotometer", The Astrophysical Journal, 521:L153–L156, (1999).

9.12.03 Subtopic: Optical Simulation and Image Analysis Suite (Semiconductor Manufacturing)

The central deliverables for this proposed solicitation is the development of a software suite for the 3 dimensional analysis of features measured with advanced optical techniques. The software package is to allow optical component and illumination wavefront analysis as well as image analysis. It is central to the package to enable 3 dimensional manipulation and analysis of the images as well as rendering and image enhancement. In addition, advanced metrology and edge (profile) analysis as defined in the following context.

We are interested in developing a simulation code for optical metrology and image analysis. This is to enable a full electromagnetic scattering simulations of semiconductor type features as well as features which will be encountered in nanotechnology and high resolution optics. We have begun to develop an advanced methodology for high resolution optical microscopy of features well below the optical wavelength. Accurate modeling of these features is essential to accessing the information contained within the intensity profiles. In addition to modeling the features correctly, image analysis in 3 dimensions is a critical aspect of the analysis. The software needs to be able to manipulate, filter and perform edge detection in sophisticated ways. That is, simple edge thresholds are no longer adequate and more sophisticated full profile analysis is required to determine feature size, geometry and position.

Likewise, the model must be capable of allowing a variation of the optical parameters and complex illumination wavefront engineering. The model should provide the basis to test key alignment and engineering aspects of the illuminating wavefront in such a way as to enable design and testing of the optimum optical configuration which provides a discernable scattered electromagnetic field which can in turn be fully analyzed to extract feature information such as size and geometry. Key elements of the optical setup need to be tested and optimized. Key materials parameters should be inputs to the software code to enable accurate modeling of the features of interest. Current available optical simulation code generally allows optical system design and test but only with ray type optics and not complete proper electromagnetic scattering and wavefront analysis.

Expectation for the first phase is a demonstration of the key components with a final product delivered at the end of phase 2. The basic physics and key equations which represent the physical situation should be written up and explained at a moderate level. Deliverables include a working algorithm as executable code. Though access to NIST capabilities should not be necessary, it may occur as deemed useful by NIST.

9.12.04 Subtopic: High Extinction Ratio 100 ps Transmitter at 850 nm

The NIST Quantum Information Testbed project is establishing a high-speed free-space quantum key distribution platform with an emphasis on demonstrating key generation at rates comparable to network data rates. To operate at high speed we focus on fast lasers which are strongly attenuated to approximate single photon sources. With this approach it is of primary importance that the extinction ratio of the source be large enough that the likelihood of emitting a photon when the transmitter is in the ‘off’ state does not significantly contribute to the error rate of the overall system. Moreover, timing concerns require that the sources operate at a pulse repetition rate in excess of 1 GHz, and with a duty-cycle on the order of 10% or lower. NIST seeks proposals for a transmitter capable of generating 100 ps FWHM data pulses at repetition rates in excess of 1 GHz, and with an extinction ratio of 30 dB or better. For compatibility the source should accept ECL levels at the input, and the output should be at a single frequency near 850 nm, the jitter must be less than 50 ps, the pulse amplitude should be stable to within 10%, and the polarization state must be stable. We will accept proposals for both novel laser sources and those based on external modulation. Phase 2 work should result in the delivery of a working prototype for use in the testbed. Further information on the testbed project is available at http://qubit.nist.gov.

Though not necessary, NIST would consider working collaboratively with the awardee.

9.12.05 Subtopic: Programmable Polarization Mode Dispersion Emulator

The polarization mode dispersion (PMD) of an optical fiber is typically described as the mean differential group delay (DGD) of the fiber measured over an appropriate wavelength range. At a given time and/or wavelength, the instantaneous value of DGD and the second-order PMD (SOPMD) components can take on a range of values that follow well-known joint probability statistics [1]. To test the performance of fiber optic communication systems in the presence of PMD requires emulators that can provide deterministic and repeatable DGD and SOPMD magnitudes over the range expected by the statistics.

This solicitation requests the development and construction of a programmable PMD emulator (PMDE). The PMDE apparatus should generate user-selectable combinations of DGD, depolarization, and polarization-dependent chromatic dispersion with 2% accuracy over the optical communications C-band (ideally, C- and L-band) and 22o ± 5o C temperature range. Arbitrary combinations of DGD and SOPMD should be selectable through a computer interface. Ideally, continuous values of DGD and SOPMD should be obtainable, but if not, the resolution should be stated. The available range of DGD and SOPMD values should fully encompass 99.999% of the DGD/SOPMD states that occur in a 30 ps fiber (for 10 Gb/s transmission, though the design should be scalable to 40 Gb/s transmission). The PMDE should have single-mode fiber input/output connections to facilitate use in optical fiber systems and have < 5dB insertion loss. PMD emulators that provide correct DGD and SOPMD statistics but cannot provide stable, user-selectable DGD/SOPMD combinations are not of interest.

Phase 1 goals should include 1) a design of PMDE hardware including a complete and detailed description of known and predicted obstacles to the successful implementation of this design, 2) modeling that demonstrates the achievable range of DGD, depolarization, and polarization-dependent chromatic dispersion values, the accuracy and temperature stability of these values, and the wavelength range of operation, 3) modeling software and/or an example graphical user interface that demonstrates operation of the PMDE, and 4) a simplified prototype artifact demonstrating the feasibility of the proposed design.

Phase 2 goals include the delivery of a programmable PMD emulator with graphical user interface for keyboard operation and digital interface for computer-automated use, provided with the executable and source codes. Upon prior agreement, NIST may provide measurements of DGD, depolarization, polarization-dependent chromatic dispersion on prototype optics to assist Phase 2 efforts.

References, for example:

Foschini, G.J.; Nelson, L.E.; Jopson, R.M.; Kogelnik, H., Photonics Technology Letters, IEEE , vol 12 , pp. 293 -295.

9.13 RADIATION PHYSICS

9.13.01 Subtopic: An Advanced Electron Beam System for Highly-Charged-Ion Production & Trapping

Highly charged ions (HCI) are used in a growing number of applications in such diverse areas as microelectronics, nanotechnology, quantum computing, medicine, and biotechnology.[1] One of the key components of HCI production in an EBIT device is the electron beam system, which includes an electron gun, a beam optics system, and a collector. A high quality electron beam facilitates analysis and interpretation of data, and control of the HCI production processes. It is desirable, for example, to have a very uniform, high density electron beam in the production region, and to minimize the heat dissipation in the beam dump (collector). Such a system is not only useful for HCI applications, but can be beneficial also to a host of analytical methods that require an electron beam. Proposals for new applications of highly charged ions will also be considered. The system would be deliverable for the Phase 2 project.

Reference:

[1] J.D. Gillaspy, “Highly charged ions,” J. Phys. B: At. Mol. Opt. Phys. 34 (2001) R93-R130.

9.14 TECHNOLOGIES TO ENHANCE FIRE SAFETY

9.14.01 Subtopic: Advanced Building Information Systems

Modern buildings have fire detection systems that provide information from detectors in the building to fire alarm panels. These nodes and display units are generally located in a location designated as the fire fighter entry for the building. Current use of such systems is focused on identifying nascent fires such that warnings can be provided prior to loss of life or extensive damage. However, the most effective use of resources for firefighting and occupant rescue requires that the location and size of the fire be determined as well as the initial indication of such events and that information be made available outside of the building. If this information could be provided directly to the fire services, both dispatch and in a vehicle, it would improve the efficiency and safety of their operations. This presents a major opportunity for the introduction of new products that improve efficiency for the fire fighting community. Of particular interest are neural networks for early detection and rejection of false alarms (using current or new transducers), mathematical techniques that provide data fusion from multiple sensors, scalable technologies that provide prioritized “data-out” service over a wide variety of communication paths, and display schemes which conform to the new NFPA 72 Chapter 4 guidelines and are accessible over small footprint displays.

Proposals for incremental advances to existing fire detection are not solicited; however, proposals that address only a portion of this research are welcome. In Phase 1, a feasibility algorithm as a working example will be deliverable. In Phase 2, a working example device will be deliverable.

9.14.02 Subtopic: Enhanced Fire Fighter Visibility

In response to structure fires, fire fighters typically enter structures to locate possible victims or conduct fire suppression. Structure fires often produce sufficient smoke to make it hard for fire fighters to maintain contact with each other. Research is required to determine if technology can allow fire fighters to maintain contact with other fire fighters in hot, steam and smoke filled rooms. This contact could be visual, such as a strobe light tuned to that part of the spectrum visible by thermal imagers or infrared cameras, or it could be acoustic, such as a system that emits a series of beeps when a fire fighter is aligned with another fire fighters. The frequency of the beeps or strobe flashes could increase as a fire fighter moves closer to a second fire fighter. The technology needs to provide sufficient information to the fire fighter so that the location of the second fire fighter can be quickly and correctly ascertained. This technology must be able to not alert a fire fighter that a second fire fighter is in the smoke filled room, but must be able to indicate whether the second fire fighter is to the front, rear, left or right side, of the first fire fighter. The system should also be able to handle multiple fire fighters so that if there are four fire fighters in a room, that each can understand that there are four separate fire fighters in the room. The technology used to maintain contact should not require the use of the hands of the fire fighter who is already carrying other equipment, such as hoses, axes, or extinguishers. This technology could be incorporated into existing fire fighter equipment, such as hoses, turn-out gear, extinguishers, helmets, Personal Alert Safety Systems (PASS), or self-contained breathing apparatus. The technology needs to be extremely light weight so to not burden the fire fighter with significantly more weight.

Proposals for incremental advances to existing reflective markers for protective gear or light sources are not solicited; however, proposals that address only a portion of this research are welcome. Phase 1 will demonstrate feasibility. In Phase 2, a functioning system for eight fire fighters will be delivered to NIST.

9.14.03 Subtopic: Distributed Multi-Nodal Voice/Data Communication for Fire Fighters

Fire ground communication between fire fighting teams and between teams and incident command typically utilize hand held radios. Hand held radios may provide adequate communication when both parties are outside of buildings, but as a fire team moves inside a structure, the ability to communicate tends to degrade quickly. This is especially evident if the walls of the structure contain significant amounts of metal. Metal, such as aluminum siding or the aluminum facing on insulation, can be sufficient to prevent VHF, UHF, and ultra-wide band radio transmission. Research is required to determine if a series of distributed nodes could be used to relay both voice and data communications. Each node would have to be capable of receiving information from other nodes and then be able to relay that information out to other nodes until the information is communicated to the incident command that is typically located outside the structure. Each node would have to be able to “see” or maintain radio contact with other nearby nodes. This series of nodes need to be able to compensate if one or more nodes are suddenly removed from the network by thermal damage or structural collapse. The nodes will include voice communication between individual team members inside the structure, but can also communicate with incident command. The nodes will also link the fire teams and incident command for the transfer of data, such as “fire fighter down” or PASS device alarms. This technology could be incorporated into existing fire fighter equipment, such as hoses, turn-out gear, extinguishers, helmets, Personal Alert Safety Systems (PASS), or self-contained breathing apparatus. The nodes could also take the form of small deployable packages that are distributed by a fire fighter, by insertion into a room through a closed or open window, or by radio controlled insertion robotic devices. However, each node must be extremely lightweight, including power source, in order not to burden the fire fighter with significantly more weight.

Proposals for incremental advances to existing radio technology are not solicited; however, proposals that address only a portion of this research are welcome. Phase 1 will demonstrate feasibility. In Phase 2, a functioning group of nodes will be delivered to NIST for further study.

9.14.04 Subtopic: Sensing for Advanced Warning of Structural Collapse

One of the major risks to firefighters in burning structures is that the fire will have weakened portions of the structure. Many firefighters are killed each year when a structure give way beneath them or a portion of the structure falls on them. This occurs most often in house fires. Fire incident commanders need to have reliable means to assess whether or not a structure is safe for firefighters to enter or remain inside performing search and rescue and fire fighting activities. NIST seeks a practical device that can be used to reliably assess the structural integrity of burning houses. The sensing device needs to be self-powered and send warning alarms to command locations on the site. If physical contact with the structure is required, the sensing device needs to be readily mounted by firefighters. Information about the expected sensitivity to partial collapse and amount of early warning provided for escape before collapse of the sensing device need to be documented. The contractor will make a prototype device available to NIST for evaluation. Human or animal testing should not be part of this research. Those submitting proposals should be aware of research performed by Professor Ziyad Duron at Harvey Mudd College in Claremont, California to use the natural fire induced vibration of a structure as means to provide advanced warning of structural collapse. A prototype device is expected to be delivered during Phase 1 of the project.

9.15 X-RAY SYSTEM TECHNOLOGIES

9.15.01 Subtopic: Very Large Area High Efficiency Soft X-ray Fluorescence Detectors

NIST seeks the design and construction (delivery of prototypes) of practical high efficiency (greater then 20%) very large area (100 square centimeters or greater) soft x-ray fluorescence detectors for materials science applications of x-ray absorption spectroscopy at our soft x-ray synchrotron radiation facility (0.3 to 1.5 keV). In particular these new detectors will be coupled to a new high efficiency wavelength dispersive system using synthetic multilayers. The synthetic multilayer system utilizes arrays of graded flat multilayers and is tunable but does not focus, thus a very large area high efficiency soft x-ray detector is needed. The new soft x-ray detector must be high vacuum compatible and can be energy dispersive although this is not a requirement. The detector must operate in the single photon counting mode and be fitted with the necessary preamplifier electronics to produce voltage pulses for counting. The layout of the detector maybe a single large element design or utilize an array of smaller detectors to build up a large area unit. The delivery and testing of prototypes at NIST synchrotron facilities can be possible in cooperation with NIST personnel.

The successful development of practical high efficiency (greater then 20%) very large area (100 square centimeters or greater) soft x-ray fluorescence detectors would be a very significant advance in the application of x-ray absorption spectroscopy (XAS) at synchrotron research facilities in the United States. XAS is a valued analytical tool for many companies and is routinely applied for many practical structure function problems (e.g. catalysts, polymers, and buried interfaces).

9.15.02 Subtopic: Ultra-high-vacuum (UHV) Compatible Analytical Wavelength Dispersive X-ray Spectrometer

NIST has need of a UHV compatible wavelength dispersive (i.e., diffraction-based) x-ray spectrometer (UHV-WDS) for elemental analysis with electron and photon excitation. The current WDS detector designs employ a gas-filled flow proportional counter for X-ray detection. This design is not compatible with the UHV systems on newer generation electron beam analysis systems employing field emission tips. Isolation windows to separate the low-vacuum of the detector (10-4 P) from the high or ultrahigh (<10-7 P) chamber vacuum are not practical because of the absorption of low energy x-rays (E < 1keV) by the window and problems with engineering existing electron columns to accept retrofitting of column windows. In this solicitation we are seeking innovative detector designs that do not use the conventional gas-filled flow proportional counter for x-ray detection and still provide high speed counting comparable to the conventional detector design. These systems may include but are not limited to technologies such as silicon drift devices and pin diode systems. The UHV-WDS will have an energy range from 100 eV to 10,000 eV with a selection of WDS diffractors (e.g., LiF, pentaerythritol (PET), thallium acid phthalate (TAP), and synthetic multilayer structures such as Mo-C and W-C). The output of the UHV-WDS will be an ASCII file of counts per channel versus channel number. The UHV-WDS will be controlled by a computer that will permit stepping from one specified peak position to another, dwell for a specified time, and digital recording of the peak and background intensities. A prototype detector will be delivered to NIST and tested during Phase 2.

NIST will be willing to collaborate with the awardee.

9.15.03 Subtopic: High-Power Industrial/Medical X-ray Tube with Minimal Heat Generation

In industrial radiography, computed tomography including medical and radiation processing applications, high-intensity x-ray beams (100 keV to 300 keV) are employed to minimize exposure times or maximize product throughput. High-power x-ray tubes are most often used for these purposes. Much of the heat generated when the electron beam strikes the x-ray target is absorbed in the anode. When high-power electron beams are used, this excess heat must be dissipated rapidly to avoid overheating the anode, which could cause the x-ray target to erode and lead to premature failure of the device. Typical industrial units employ a closed-loop coolant system to extract the heat from the anode. While fairly efficient, these systems add significantly to the weight and cost of an x-ray unit, and are subject to failure. From a design standpoint, the best approach would be to minimize the heat that is produced in the anode without sacrificing the power output of the device. Factors such as target shape, size and composition, electron beam parameters, as well as the target-to-anode coupling all impact heat generation in the anode. Through careful consideration of these factors it should be possible to design and construct an x-ray tube capable of generating high powers needed for both industrial and medical applications while operating at sufficiently low temperature for prolonged life.

Presently, NIST maintains air-kerma standards for x-ray medical diagnostics and has special expertise in the quantification of ionizing radiation effects and dosimetry. NIST can apply this expertise in the characterization of these devices and provide to industry a set of standards and guidelines that would allow them to be used effectively. Proposals must sufficiently demonstrate feasibility through modeling and careful design. Proposals submitted under this subtopic may address access to NIST facilities and staff, and delivery of a working prototype is expected.